The Dock & Harbour Authority

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The Dock & Harbour Authority

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No. 391

Vol. XXXIV.

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Editorial Comments

The Port of Tarifa.

In the handling of maritime matters there is always one quality which above all others is required for success, and that quality is practical ability; the capacity of resourcefulness to deal decisively and immediately with difficult factors and situations as they arise. No amount of theorising or mathematical formulae can replace it.

The achievement of the engineers and staff in the development of the Port of Tarifa, an account of which will be found elsewhere in this issue, is a good example of practical performance worthy of the pioneer class of engineering accomplishment. The construction of this harbour, though of relatively small dimensions, was taken on as a day-to-day job of work, organised and accomplished under difficulties of time, situation, natural elements and material supply. For example, it was a bold decision to construct the reinforced concrete caissons in the Cadiz dry dock, as this entailed a sea voyage of 75 miles over the Atlantic to Tarifa. The masterly solution to overcome economically, in time and cost, the difficulties of the silt bed on the dock floor; the readily formed plans to incorporate the wine bottle-shaped concrete pumphouse of the old dock into a breakwater head are also examples of aptitude and ingenuity.

A further point of interest is that the method of construction used was in several respects similar to that employed three years later in the construction of the Mulberry Invasion Harbours which were used on the beaches of Arromanches.

Corrosion of Iron and Steel.

The importance of efficient and economical maintenance of installations and structures will be readily recognised by those engaged in administering the complex industry dealing with ships, docks and harbours. The development of engineering technique as illustrated in new structures in ports throughout the world, and in the many new items of equipment now coming into use, has been noted in many articles in this Journal. A great deal of the attention of maritime engineers is, however, directed to the daily problems of maintenance, of which one of the most important is the prevention of deterioration due to corrosion.

On a following page in this issue, Mr. N. N. B. Ordman discusses some of the practical considerations which arise in dealing with the prevention or deterrence of corrosion in maritime works. Factors affecting the selection of the most suitable structural materials and the correct initial and subsequent treatments of these materials are referred to, as well as the many difficulties that arise in maintaining plant and structures subjected to heavy and continuous use.

This article, written from the stand point of a dock engineer, and posing a number of important questions, is an introduction to a series of articles written by Dr. J. C. Hudson, Head of the Corrosion Laboratory, British Iron and Steel Research Association, which will appear in subsequent issues. In these articles, under the title " The Corrosion of Iron and Steel and Its Prevention with Special Reference to Harbour and Dock Installations," Dr. Hudson will review the whole field of corrosion research and its practical application to maritime corrosion problems.

Ship Fires in Port.

At the annual meeting of the Sea Insurance Company held in Liverpool early this month, Major A. H. Bibby, Chairman, made some pertinent remarks concerning fire risks to ships in port. In the course of his address he drew attention to the loss during recent months of two passenger ships, the *Empress of Canada*, at Liverpool, and the *Kronprins Frederik* at Harwich. Both vessels caught fire in port and capsized " through the well-intended efforts of the shore fire brigades."

Major Bibby then pointed out that when vast quantities of water are pumped into the structure (whence it cannot readily escape) by any authority who must know little of ships' stability charts in general, and can have no particular knowledge of the individual ship concerned, it is almost inevitable that the ship will capsize, and indeed this has happened in each of three recent cases in Harwich, Liverpool and New York.

Continuing, the speaker said " there seems to be a case for examination as to whether, when a serious fire to a passenger liner occurs in port, it would be prudent, before pumping in sufficient water to extinguish the flames, to allow her, by deliberately flooding her lower holds, to settle in an upright position and so avoid many of the intractable difficulties of salvage."

We are in complete agreement with his views that " to regularise such action, an agreed policy must be reached between all parties concerned—shipowners, underwriters, port authorities and the protection and indemnity clubs, as well as the fire-fighting services." Also, his suggestion that these bodies should seek to form a unified policy, should receive serious attention " in the hope that thereby ships may be saved from becoming total losses and the ports from congestion through the protracted salvage operations."

Large Dry Docks.

During the last World War, the provision of a sufficiency of large dry docks in various parts of the world was a matter of major importance, and since the war it has lost nothing of its urgency. Forecasting the future dimensions of vessels is also a subject which, for many years, has been the concern of dock authorities, not only for the purpose of constructing dry docks, but also of enclosed docks, wherever these may be necessary by reason of the range of tides.

The trend in ship sizes has been debated at many Engineering Conferences, some being convened by the Institution of Civil Engineers, notably those of 1907, 1921 and more recently, that of 1951 at which a paper on Dry Docks was submitted by J. Guthrie Brown. The subject was also dealt with at the twelfth International Navigation Conference in 1912, and by Dominions Royal Commissions of 1913, 1915 and 1918. As a result, some valuable recommendations for the solution of the problem of providing adequate accommodation for future shipping were made and acted upon when new docks were built or existing facilities were enlarged.

Generally speaking, however, most of the dry docks built during the last century have become obsolete, or are tending to become so, by reason of the increased dimensions of modern vessels. The principal limitations of the dry docks in the United Kingdom are

Editorial Comments—continued

in respect of the width provided, rather than of the depth, and attention has been drawn to the general inadequacy of dry-docking facilities by a paper read recently to the Institution of Naval Architects. This paper, by Mr. E. L. Champness, a vice-president of the Institution, reviews the present position regarding large dry dock accommodation in world ports, the trend in ship dimensions, and future docking requirements.

The author states that the United Kingdom, in relation to its mercantile ship-owning interests, is in a declining position through failing to keep pace with the demands for an increase in the size of private and public docks where ship repair work could be carried out. He also draws attention to the competition which the ship-repairing industry of this country will have to face in the future from Continental ports. Particularly is this so in respect to the large number of oil tankers of 28,000 tons deadweight and upwards which are now under construction or on order.

That there is a deficiency in the number of large dry docks is undoubtedly true, but the reasons for this unfortunate position are not readily apparent. No doubt the high cost of building or reconstruction of dry docks is a major cause, and it has frequently been suggested in this respect that considerable financial difficulties arise through the absence of a firm policy in regard to taxation relief and depreciation allowances. Further, at some ports, it would be difficult to make provision for larger vessels by means of alteration to an existing dock, for the reason that it would be out of commission for at least $2\frac{1}{2}$ to 3 years. It is possible also that there may be an absence of suitable sites.

Whatever the validity of the reasons for the lack of facilities, in our view the present unsatisfactory position could have been alleviated by a greater measure of collaboration and consultation between shipowners and dock authorities before any shipbuilding proposals were put into effect. As has been frequently stressed in past issues of this Journal, a long-sighted policy is needed to ensure that the majority of ship repair work may continue to be executed in this country and not be diverted abroad. In this the Government should be particularly interested, and it is to be hoped that an early conference will be arranged among all those concerned.

Takoradi Harbour Extensions.

The work of over seven years planning and construction culminated on April 24th last, with the official opening of the extensions to the Port of Takoradi by Sir Charles Arden-Clarke, C.G.M.G., Governor of the Gold Coast.

The extensions, which were begun in 1949, have cost £3,250,000, and represent one of the largest post-war harbour improvements in the Western world. They were planned to double the annual totals of export and import cargoes, which amounted to about 1,000,000 tons, but already cargoes are being handled at the rate of nearly $2\frac{1}{2}$ million tons a year, and there is every prospect that this figure will soon reach 3 million tons.

Takoradi is the main outlet for the products of the 80,000 square miles of tropical hinterland which comprise the Gold Coast, and as recently as 25 years ago it was only an unpretentious fishing village. To-day it is a thriving town with 25,000 inhabitants and can look to an assured future. Since 1947, the deep water quay at the port has been extended by 1,400-ft., thus providing six berths for ocean-going vessels, and so doubling the previous accommodation; 4,400-ft. of quay walls have been constructed in the timber depot, and two sawn timber sheds have been erected. A new bauxite berth has also been provided, whilst a new oil berth is being built on the north face of the Lee Breakwater.

The whole undertaking is a remarkable achievement and is a further proof of the skill and ingenuity of British engineering. Tribute must also be paid to all concerned with the port's administration. The contractors were Messrs. Taylor Woodrow (West Africa) Ltd., whose headquarters are in London, and the works were designed and supervised by the Consulting Engineers, Messrs. Rendel, Palmer and Tritton, of London. Our readers will remember that a full account of the engineering work involved in the scheme formed the leading article in the April, 1952, issue of this Journal.

Topical Notes

Suggested Decasualisation Scheme for Pakistan.

The Government of Pakistan is reported to have set up a committee to consider the introduction of a decasualisation scheme for the country's dock workers. Pakistan has two major ports—Karachi and Chittagong, and the dock labour force totals approximately 4,750. Of these, about 2,500 are employed by the Port Trust, some 1,500 by registered stevedoring companies, 350 by lighterage firms, and about 400 on bunkering. The employment of Port Trust labour, especially stevedores, is extremely irregular. It is estimated that between 2,000 and 3,000 dockers present themselves for work each day, but only 1,500 of them actually obtain employment. As a rule, dockers work for only ten to twelve days per month.

Australian Stevedoring Industry Report.

The Australian Stevedoring Industry Board, in its report for the year ended June 30, 1952, criticises the attitude of both shipowners and wharf labourers towards work in Australian ports. It says that by June last year congestion at the ports which was so marked during the immediate post-war years, had disappeared. Nearly 39 million tons of cargo, a record amount for Australian ports, had been handled in 1951-52. The employers and employees on the wharves were foreigners in thought and approach, and many seemed to have in common only a partisan outlook.

The decline in the volume of shipping which had begun to appear in April last had created a problem of surplus waterside labour, but the shipowners, who had long complained of labour shortages, had not made the maximum use of the available man-power since this reversal in the labour situation. There had been an improvement in the turn-round of shipping, but it appeared to have been limited to the extent that the shipowners or stevedores desired or allowed. In 1951, the average time taken to unload and prepare a ship for sea was $11\frac{1}{2}$ days, but last year the time was cut to $7\frac{1}{2}$ days.

Continuing, the Report says that working conditions on the wharves were not good. On some wharves sanitation was primitive, first-aid facilities were much in the same case, and employers had regarded the welfare of casual workers much too lightly. The Waterside Workers' Federation was far from blameless in the perpetuation of the low standard of amenities, which was symbolic of archaic thinking among all concerned.

In the last quarter of the year there was a reversal in the dockyard employment situation. During the year there was an abrupt slackening in the flow of shipping, and acute labour shortages in Melbourne and Sydney were replaced by surpluses. This turn of events swept away some of the old problems facing the industry, but created new ones.

Tokyo Port to be Renovated.

Plans to reconstruct and enlarge Tokyo Port facilities at an estimated cost of Y900,000,000, during the forthcoming fiscal year, to make it into an international port, were announced recently by the Tokyo Metropolitan Government.

Tokyo Port, which has been under the control of the U.S. Army for the past eight years, is expected to be restored to Japanese authority by June next. Meanwhile, 24 municipal warehouses along the Hinode and Shibaura piers were released by the U.S. Army last March.

The reconstruction of Takeshiba and Hinode piers and proposed enlargement of Harumi pier are expected to be completed during the new fiscal year to accommodate 10,000-ton liners, and it is planned to widen the existing fairway from 110 to 150 yards. Two freight piers, one for coal and the other for iron and steel, are scheduled to be repaired and equipped with new loading machines.

New Union for Bombay Dock Workers.

It was recently announced in the Indian press, that plans are in hand to form a united union of all dock workers at the Port of Bombay, who are at present represented by five independent organisations. Preliminary discussions on the merger were begun during February last, and if the proposed amalgamation is carried into effect, the new organisation, for which the name "Waterfront Workers' Union" has been suggested, will have a membership of nearly 25,000.

The Military Port of Tarifa

An Unusual Harbour Construction

(Specially Contributed)

IN THESE DAYS of manifold appliances, ready to hand information, intensive research into all forms of human knowledge, highly trained craftsmen and professionals; matter and qualities that make for a self sufficiency, one might be tempted to think that the quality of resource and make-do would be weakened. On the contrary, there is ample evidence that it is strengthened, particularly in the engineering profession.

It was Ruskin who said that he was always filled with wonder and amazement when he observed the prow of a vessel cutting its own path through the roadless oceans: how much more amazed would he be to-day if he were to see huge blocks of stone (monolithic concrete) braving the waters of the Atlantic. Of course the aesthetic side—for Ruskin was before all else an Art critic—would not be his period for the cubists were not then circulating.

The Mulberry Harbour of Arromanches caught the imagination of the world, and it would not be disputed that the combined efforts of naval, military, scientific and engineering elements deserved the glory of miraculous achievement. It was a war-time construction of different services working to a common end against relentless forces of prodigious power. It was successful; the miracle came to pass, and the grand exploit overshadowed all the details.

That was June 1944.

The following review deals also with a war-time achievement, which had several features of great interest and also to some extent close similarity to the breakwaters of the Mulberry Harbour. The description of these works has just recently been released by the Spanish engineers Antonio Duran Tovar and Manuel Alvarez Aguirre in the " Informes de la Construccion."*

On the most southerly tip of the Iberian Peninsular there juts out into the Straits of Gibraltar a rocky tongue of land, about 12 miles from Gibraltar (see Fig. 7). The western side is full open to the broad Atlantic and on the eastern side, in the shelter of Paloma Island, there lies the Spanish Military port of Tarifa. In 1941 there was no actual harbour. The only shelter for shipping, mostly shallow draft craft and fishing vessels, was on the leeward side of Paloma Island which was linked by a causeway to the mainland and Tarifa. There was also a length of about 700 feet of unfinished rubble breakwater just west of the town of Tarifa. Near the root there was a block yard which was filled with manufactured concrete blocks left there when the work was halted at the outbreak of war.

The state of the war in Europe and North Africa in the early days of 1941 was for the Allies extremely serious and fluid, and all reliance for the safety of the remnants of the armies rested upon the efficiency of the navy to keep open the ocean highways. At this time the Spanish Government were none too secure, even with their friends. It was fearful of the shape of things in the countries about them, and took action as far as its means would allow against any breaches of its declared neutral policy. Thus in February 1941 it was decreed that the development of the port of Tarifa should be recommenced to give shelter and facilities to repair fast naval motor craft of small dimensions. These vessels were to be employed in protecting the neutrality of the Straits of Gibraltar. To this end it was proposed to build a small harbour by enclosing an area of about 20 acres of the sea by two breakwater arms: to provide moorings and berths for the naval vessels, small tankers and other supply vessels. It was further provided to build several wet docks and dry docks suitable to accommodate ships of small draught.

There was already constructed a length of rubble breakwater and it was decided to incorporate this in the complete scheme as part of the eastern arm. Towards the end of March 1941 ministerial (Public Works and Marine) orders were given to proceed with the construction according to the submitted plans as shown in Fig. 1.

The works were halted in the first instance owing to the great difficulties in obtaining supplies of materials: the position had not improved; the enormous demands of the powers at war absorbed world production. This state of things coupled with the urgency emphasized in the ministerial orders, placed a heavy responsibility on the engineers engaged on the works. Obviously this entailed careful and rapid deliberations on equivalent materials and methods. These difficulties resulted in the adoption of several unusual features of construction, and resourceful adaptation to circumstances, showing highly skilled technique in maritime engineering.

The general shape and arrangement of the harbour lay-out was resolved by the following considerations: (a) the most frequent storms came from south west by west, wave height 5 metres. The

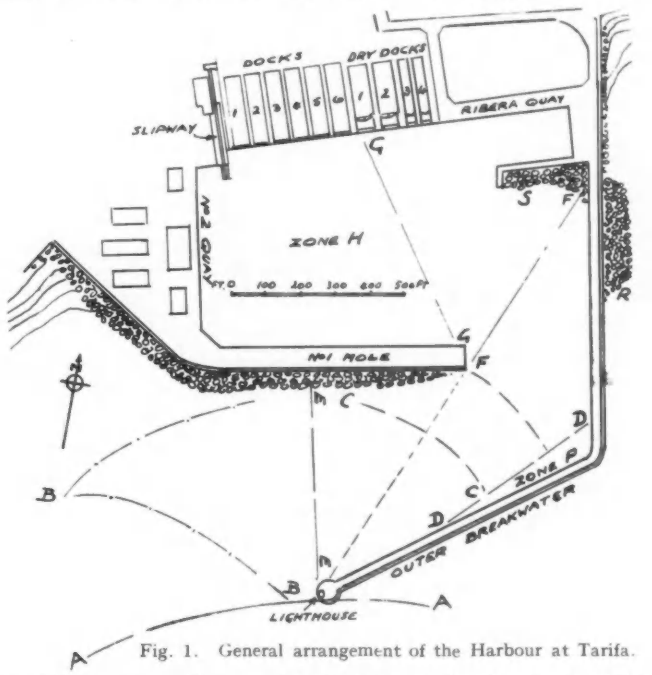


Fig. 1. General arrangement of the Harbour at Tarifa.

line AA represents the wave front about the breakwater head for this condition. On the Irribaren principle the line BB represents the edge of the limiting zone of full wave attack and between this line and the line EE the waves are assumed to expand laterally in other words to decrease in height and swing about the lighthouse head. Then the waves which enter between the harbour walls are subjected to diffraction beyond the line EE, called by Irribaren the limit of the zone of expansion. From EE onwards there ensues a reduction of wave height, in this case by refraction and energy dissipation on the flat slope of the inner harbour wall as well as diffraction; the line CC represents the advance of the crest of the freshly propagated waves, and the line DD the limit of the agitated zone.

Outside of the line DD there is the zone P which is assumed as calm. The angle made by the lines EE and DD is one radian (57.3 degrees) and were it not for refraction effects about the entrance the angle between the lines EE and BB would be 45 degrees.

Inside of the harbour the line FF represents the limit of expansion and the line GG the limit of agitation so that the zone H is assumed to be calm water.

*" Institute Technico de la Construccion y del Cemento," Madrid.

The Military Port of Tarifa—continued

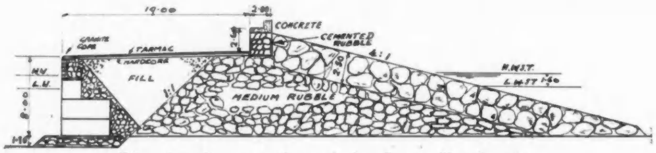


Fig. 2. Cross-section of the Inner Breakwater.

On these diagrams the line of the outer and inner harbour walls were decided in the confidence that there would be quiet moorings alongside the inner faces of both walls. Another factor taken into consideration was the deck level of the walls and the limiting depth of water to which the works should extend.

For economy and convenience the outer wall was limited to 10 metres depth of water at L.W.S.T. with freeboard of 1.70 m. above H.W.S.T. and a parapet height of 6.20 m. above high water, while the inner wall had a deck level of 1.40 m. above H.W.S.T. and a parapet height of 5.00 m. above high water.

The tidal range is 1.60 metres.

Despite the wave energy absorbing value of the flat rubble slope of the inner mole (Fig. 2) the shape of the harbour entrance with two converging walls is disadvantageous and is usually avoided but it would appear that the engineers were satisfied that disturbances of the harbour waters due to resonance and heaping up could be neglected. It is also somewhat doubtful that there could possibly be calm water at any point of the zone P when a south-west by quarter west gale of 5 m. wave height is running.

The Outer Breakwater.

That portion of the breakwater already constructed was of the vertical type of 60-80 ton blocks on a rubble foundation with a superstructure of cemented random rubble and mass concrete. On the seaward side from the root to the mid length of the breakwater arm in a water depth of about 7 metres the face was protected by quarry rubble wave breakers. About the mid point for a length of 100 metres this protection was enlarged as shown at R (Fig. 1) in water depth 4-7 metres.

In the harbour at the point S there is a spending beach formed of quarry rubble.

Although there were a large number of concrete blocks already cast lying in the block yard in the position now occupied by the Ribera quay, it was decided on the score of economy and the following reasons not to continue the breakwater extension to the same profile.

(a) The "Titan" crane used in the original construction had been carried away during a gale and replacement was impossible.

(b) The time limit of twelve months to complete the breakwaters forced the direction to seek the quickest possible method of construction.

(c) A floating crane of 60 tons capacity was available but its use would be restricted to fine weather only and therefore the number of work days would be dependent upon weather conditions. There was also the hazard of the sinking of the floating crane during any sudden arrival of long Atlantic swell.

(d) The use of relatively small concrete blocks of 60 tons bedded on rubble in the deeper water was not considered sufficiently safe.

(e) The fabrication of concrete blocks would require large quantities of cement which was most difficult to obtain.

(f) To continue the same profile as that of the existing arm into deeper water a large quantity of quarry blocks would be required as wave breakers. For a slope seaward of 2 : 1, blocks of no less than 35 tons weight would be required for waves of 5 metres height according to the Irribaren formula. As the quarry could only supply blocks of a maximum weight of 5 tons at a relatively high cost this one factor alone showed the original profile to be unsuitable. There was yet another factor of importance: it was absolutely necessary to provide moorings on the harbour side of the wall for deep draught vessels such as transports. To satisfy this condition a vertical wall of pre-cast concrete blocks would have to be built along the harbour face of the mole.

(g) The estimated time required for the rubble wall construction showed clearly that it could not be completed within the specified date.

Considering all these factors and comparing various designs of profile it was definitely concluded that pre-fabricated re-inforced concrete caissons built on shore and floated out to the site would economise materials, save time in construction, and avoid all the hazards of other methods.

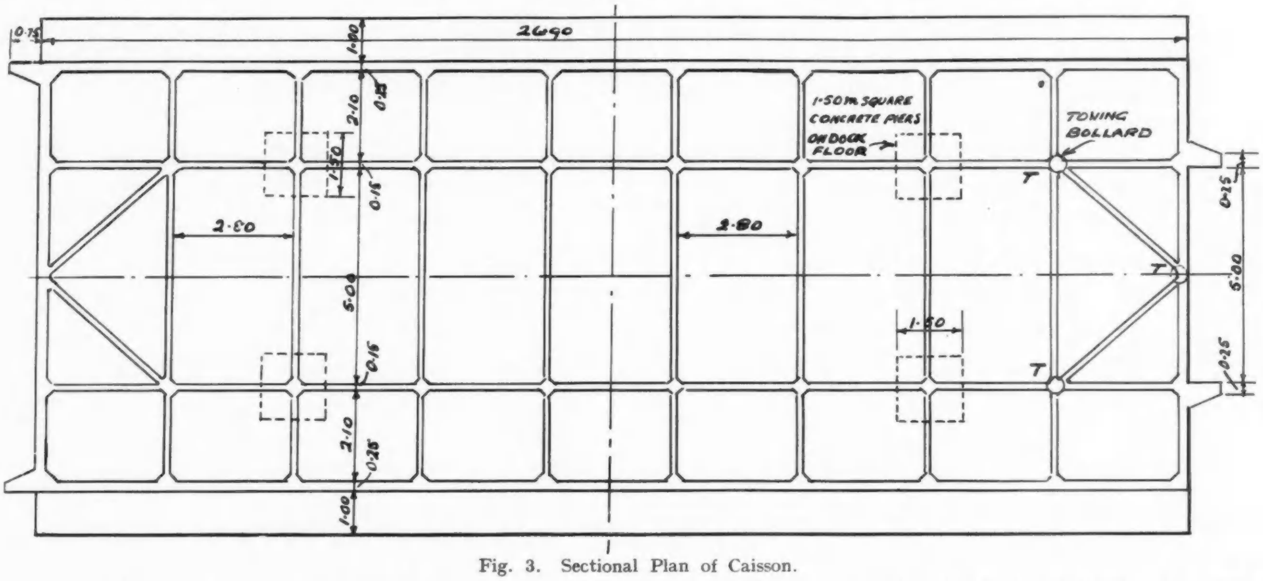


Fig. 3. Sectional Plan of Caisson.

The engineers were at first inclined to build the caissons on slipways in Tarifa but many other factors, of which labour and siting were two, made the scheme untenable. The possibility of constructing these units on the deck of the existing sea wall was also considered. Whilst working out the plans for this they heard that the old disused dry dock at Cadiz had been emptied. It was at once inspected. To their disappointment it was still unusable. A deep layer of silt lay over the bottom, the sill was not repaired, and the side walls were in a bad state.

Nevertheless the urgency of the matter brooked of no further delay: it was decided to clear it of the silt providing it could be done in a fortnight. The job however could not be done in the

The Military Port of Tarifa—*continued*

time so it was decided to leave the silt as it was and build the caissons above it.

Although this was a neutral country, taking all the circumstances into consideration, the boldness of the decision showed confidence and technical ability. The transport of huge concrete hulks on the waters of the Atlantic in full exposure had not been attempted previously, and, even granted successful construction of the caissons, the passage of 75 miles under tow was yet to be faced.

Briefly, the problem of the silt, which was found to be about 7-8 feet deep, was overcome by the building of a timber platform above it supported on stilts of timber driven down to the dock floor. This platform was also to serve as the shuttering for the caisson bases and the strength was calculated to support the weight of the caisson's base slabs only.

Considering that the weight of each of the caissons was 2,000 tons it would have been very costly to erect timber platforms to carry this load. To avoid this concrete piers about five feet square

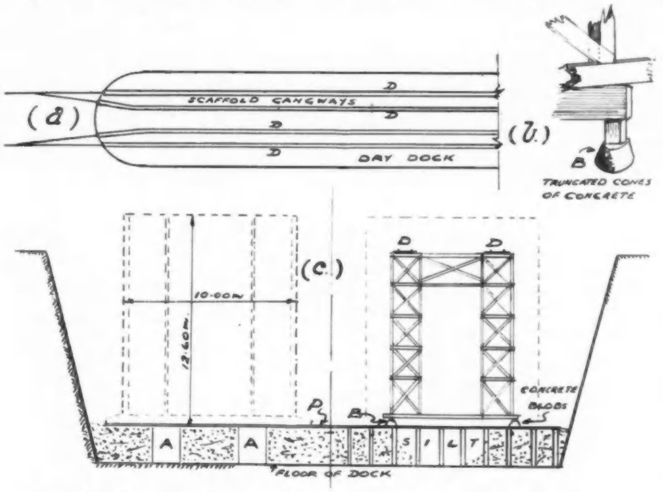


Fig. 5. Diagram of Scaffolding etc. in Dry Dock (a) arrangement of walkways and rail tracks D; (b) detail of concrete blob footings; (c) cross-section of dock showing scaffolding trestles, platform P and concrete piers A.

were built from the dock floor to the underside of the base slabs. They were located as shown by the dotted lines (Fig. 3) and were four in number for each unit. They were constructed inside a cage of timber sheeting driven through the silt and then the latter was pumped out of the inside until the dock bottom was exposed.

After the base slabs were poured the vertical partitions and skins of the caissons were carried upwards uniformly until the settlement of the timber platform under the added weight threw the total load on the concrete piers.

With the object of being able to construct the eight caissons required for the breakwater in the alloted time of twelve weeks by continuous placing of the concrete a timber scaffold was erected resting on the timber platform at the base with the top level at dock coping height (Fig. 5). This provided four walkways and trolley tracks for concrete skips as well as serving for shuttering supports for the vertical walls. The feet of the scaffolding trestles were supported on truncated conical blobs of concrete as shown at (b). The height of these small lumps of concrete corresponded with the thickness of the base slab. This shape was favoured as it ensured contact over the whole surface of the concrete when the base slab was poured and besides was the best form to resist the pressure of water on the skin when afloat.

The construction of the timber base platform was commenced June 1941 and in about four weeks not only was this completed but the trestles and walkways also. This allowed the pouring of the concrete base slabs to commence in July 1941 and in eighty-eight days towards the end of September the whole of the concrete work was finished. There were 600 cubic metres of concrete in each of the eight caissons and at least 50 per cent. of the total was used in the relatively thin walls of approximately 6 and 10 inches thick of double shuttering.

The sectional plan of the caisson shows the disposition of the partition walls longitudinally and athwartship. There were lightening holes in all transverse partition walls. At the same time as the work was proceeding on the caissons a monolithic reinforced concrete structure very like a huge wine flagon or old-fashioned decanter in shape (Fig. 6) had been recovered from the

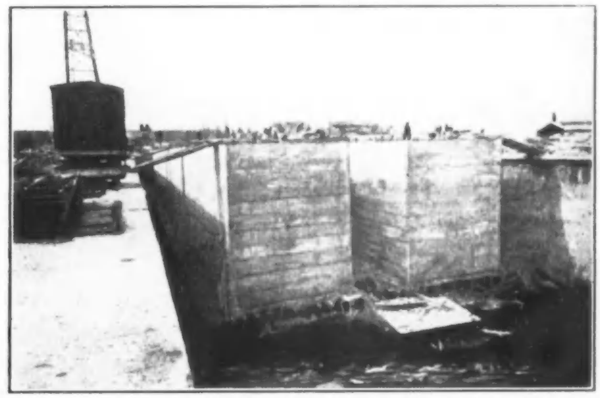


Fig. 4. Caissons stripped of Shuttering and Scaffolding and almost completed.

dry dock demolitions. It had served the purpose of a pump house for the dry dock but was now to be used after certain modifications as the core for the head of the Tarifa breakwater.

In October the floating stability of the caissons was tested and a layer of weak plain concrete 0.70 metre thick was placed over the floor of all compartments, which together with the thickness 0.30 m. of the base slab gave a total thickness of 1.0 m. The exterior of all units including the wine bottle head was given a good coating of cement wash and at each corner of the caissons a scale and figures indicating the draught were painted. Towing and mooring bollards T, were fitted to the top deck; three hand capstans were also fitted for sinking purposes and a petrol motor pump was installed to deal with ballast water. Gangways and shelters for the crew completed the equipment.

Transport of the Caissons.

As a preliminary to the operation of towing the caissons the full 75 miles from Cadiz to Tarifa, arrangements were made with the

Fig. 6. The salved Reinforced Concrete Pump House being prepared for its journey by tow to Tarifa.

Meteorological Observatory of Madrid to give forecasts of the most favourable periods in which to make the attempt. At that time this was not so easy of accomplishment on account of the restriction of information by the warring nations of the conditions in the Atlantic. Information of the approach of storms many hundreds of miles away in the mid-Atlantic would have been of considerable assistance. Most of this weather information was considered as top secret. Under the circumstances the method adopted was

The Military Port of Tarifa—continued

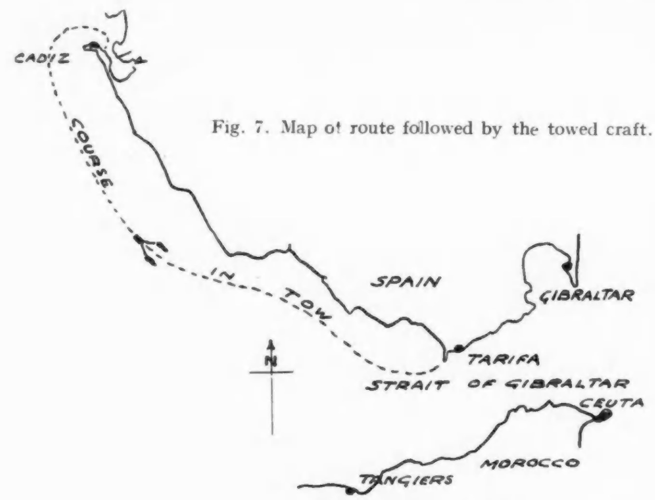


Fig. 7. Map of route followed by the towed craft.

the site of the outer breakwater had been dredged to the profile shown in Fig. 8 to a depth of 14 m. below low water and the rubble had been tipped to grade. There were 140,000 cubic metres of dredging all carried out by the suction dredger, since the exposure was too great for the bucket dredger of the port. The rubble tipping barges followed close upon the dredger so that there was no delay between one operation and the next.

The end of the existing arm was squared up with the 80-ton concrete blocks, already fabricated, to facilitate the junction with the caisson wall. The blocks were deposited by the floating crane. The final preparation of the bed rubble to receive the units was done by a team of divers. The gaps left between each two adjacent caissons of about 1.50 m. were bag concreted. When more time was taken in the placing of any unit than elapsed in the fetching of another from Cadiz the new arrival was temporarily sunk on the sandy sea bed in the shelter of the breakwater already constructed. For the purpose of sinking, valves operated from the deck were disposed in positions suitable to feed the three longitudinal compartments to the extent necessary to control the amount of the sinkage and the trim of the hulk.

To position the units six mooring ropes were used: one forward and one aft to govern the longitudinal placing whilst the remaining four were placed, one at each corner, to control the transverse placing on the longitudinal axis. When brought into position ready for sinking the valves were opened to flood the units gradually whilst the mooring ropes were taken in sufficiently to keep them tight on the capstan drums. When the base of the unit was about a metre above grade the valves were closed gradually so that it remained floating in its approximate location. Then the line was checked by a theodolite placed on the existing wall: the moorings were tightened up as necessary to give the true line, and then the valves were full opened to flood the chambers quickly and bring the unit to its final site.

After grounding the central longitudinal compartments C were filled with sand and side compartments B were filled with gravel and subsequently injected with cement slurry through 2-in. diameter pipes which were run into the compartment before filling. Above this, cemented rubble A was built up into the sectional form shown in Fig. 8. A temporary rail track was then laid over the rubble top; the reinforced concrete deck slab was not completed

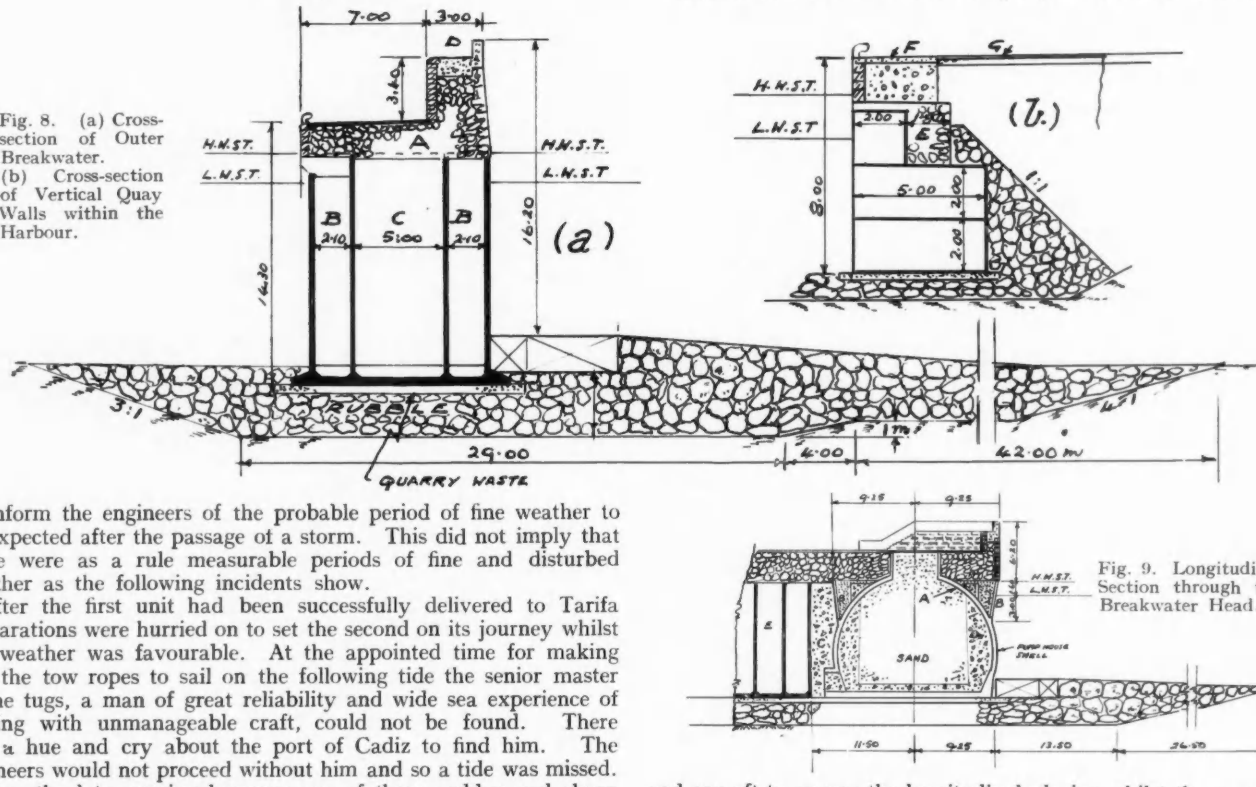


Fig. 8. (a) Cross-section of Outer Breakwater. (b) Cross-section of Vertical Quay Walls within the Harbour.

to inform the engineers of the probable period of fine weather to be expected after the passage of a storm. This did not imply that there were as a rule measurable periods of fine and disturbed weather as the following incidents show.

After the first unit had been successfully delivered to Tarifa preparations were hurried on to set the second on its journey whilst the weather was favourable. At the appointed time for making fast the tow ropes to sail on the following tide the senior master of the tugs, a man of great reliability and wide sea experience of dealing with unmanageable craft, could not be found. There was a hue and cry about the port of Cadiz to find him. The engineers would not proceed without him and so a tide was missed. During the late evening however one of those sudden and sharp south-west storms swept up a considerable sea and all concerned were thankful that the skipper had for once erred.

The most serious mishap of the towage occurred during fine weather off Cape Trafalgar. The sea surface was little disturbed by a fair breeze but there was a heavy south-west swell of great length and height, trough to crest, rolling into the Straits. Although the tow made little headway to the S.E. by S. the 600 feet long towing cables were vibrating like the strings of a fiddle and towards night when only a few miles from Tarifa the cables parted. To make matters worse the breeze freshened and all night long the caisson drifted until the cables were again made fast, even then the heavy swell made progress difficult. Three tugs were used for the tow, having a combined horse power of 2,000 h.p.

Sinking of the Caissons.

During the construction of the caissons the sub-foundation work on site was prepared and on the mainland a quarry was opened up to supply the rubble. At the time of arrival of the first unit

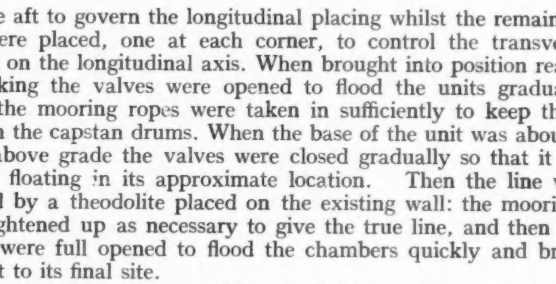


Fig. 9. Longitudinal Section through the Breakwater Head.

The Military Port of Tarifa—*continued*

until later when it was hoped that the initial settlement would have passed its peak rate. Little difficulty was experienced in completing the caisson wall to the breakwater head.

The Breakwater Head.

The curious form of the old R.C. pumphouse (Fig. 6) salved from the dry dock at Cadiz was prepared to receive additions to its superstructure before leaving the dry dock. It was ballasted for safe stability at sea; fitted with towing bridle and made the

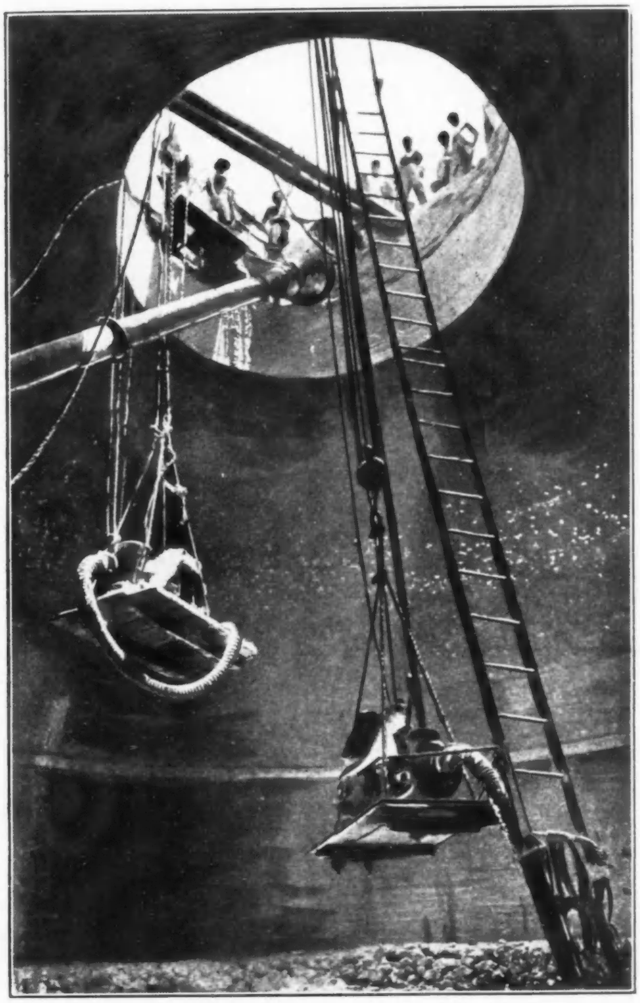


Fig. 10. Interior view of Pump House after sinking into position preparatory to filling with concrete and sand to form core of breakwater head.

journey to Tarifa in the record time of twenty hours without mishap. On arrival the circumferential wall B (Fig. 9) of reinforced concrete was added: the bottom edge resting on the lower original ledge shown in the illustration (Fig. 6).

When placing the form in the position for final sinking one of the mooring ropes parted and the whole mass started gyrating like a spinning top and as the top lip of the flared wall was only an inch or two above water level it was feared that the whole outfit would become submerged. Luckily the turning stopped and the rope was again secured. No further incidents occurred and it was sunk fair in position.

The concentric ring space between the wall B and the skin of the main unit was then filled with concrete to form kentledge. Further kentledge was obtained by covering the base of the bottle inside with 0.50 m. thick concrete laid by tremie (Fig. 10). The inside was then pumped out and the concrete walls D were erected. The inside was then filled with sand and the superstructure of cemented and random rubble was completed.

As before, the junction with the last caisson E was made with bagged concrete fill C after initial settlement.

The final facing at the parapet head was of selected coursed stone and a fine monumental tower was raised at the head for the lighthouse.

Inner breakwater.

The construction of the inner wall proceeded concurrently with that of the outer wall to the profile shown in Fig. 2. Most of the stone about the axis of the wall was transported from the quarry and dumped in place by 10-ton tipping lorries. The rest was deposited by a 10-ton crane running along the wall, and floating tipping barges.

The whole of this work was carried out in two and a half years.

Lloyds Register of Shipping

Excerpts from Annual Report for 1952

The most recent statistical survey of the world's mercantile fleet shows that it has increased during the past year by over 2.9 million tons gross and there is no doubt that if it were not for heavy taxation and shortage of steel, which in certain countries are prohibiting orders and retarding production, this growth would have been accelerated. The present world tonnage of 90.2 million tons gross is over 30 per cent. in excess of the pre-war figure, although it must not be forgotten that this total includes about 12½ million tons still in reserve in the United States.

The number of ships comprising the world fleet shows an increase of barely 6 per cent. over the figure for 1939, which emphasises that the growth is mainly in size of unit. The fall in tramp production on the one hand, and the greatly increased size of oil tankers—now forming such a big proportion of the world's shipping—on the other, have contributed largely to this phenomenon. Among tankers recently completed or under construction ships of 18,000 tons deadweight are common and an increasing number with capacities of 28,000 to 30,000 tons are now coming into service. Tankers of much larger capacities are under construction or are projected.

The lively demand for steel continues to stimulate the construction of ships specially designed for the carriage of ore and during the year two ships built for alternative ore/oil of 24,000 tons deadweight, both classed with Lloyd's Register, have been completed.

The total number of ships completed to the Society's classification during the year under review was 524, with an aggregate gross tonnage of 2,522,941. These figures are better than the previous year's by 52 ships of 371,059 tons and represent 60 per cent. of the total tonnage built during 1952 throughout the world. The year's output included 132 oil tankers, aggregating 1,383,477 tons gross.

Work in Hand at 31st December, 1952.

For the second year in succession it is possible to report that the tonnage being built at the end of the year to Lloyd's Register or British Corporation class was the highest figure recorded since 1921. The number of ships under construction was 595, aggregating an estimated 3,847,000 tons gross. This total is 63 per cent. of all the merchant shipping under construction in the world; it includes 180 tankers of 2,281,800 tons gross.

Cargo refrigerating installations were under construction at the end of the year to the Society's classification for 52 ships in United Kingdom yards, with a total capacity of approximately 4.4 million cubic feet, and for 55 ships abroad, with a capacity of 2.9 million cubic feet.

In addition, a number of cold stores, extensions to existing stores, and refrigerating plants for other purposes were being constructed under the supervision of the Society's surveyors.

Developments in Ship Design

The tendencies towards specialised designs, higher speed and larger cubic capacity for dry cargo ships continue. Several cargo ships of about 8,000 tons deadweight with propelling machinery aft are coming into service, and one large passenger ship with the machinery situated towards the after end is under construction. This arrangement offers advantages in cargo stowage and handling; in

Lloyds Register of Shipping—continued

passenger ships the planning of accommodation may be simplified, and the position of the funnel may reduce smoke nuisance on passenger decks. The performance of these ships will be watched with interest.

Developments over recent years in the design of cargo ships with machinery amidships have tended to increase appreciably the hogging bending moments in the loaded condition. The change from the poop, bridge and forecastle ship to the shelter decker with provision of increased cargo space at the ends of the ship, concurrently with increased speeds requiring finer underwater forms, results in greater weight and less buoyancy at the ends of the ship.

In the case of tankers, however, where the sagging bending moment is the more critical, increase in length of cargo space relative to length of ship has a beneficial effect. In the structural design of modern tankers, longitudinal framing, either complete or at bottom and deck is now universal. Bulkheads of the trough or corrugated form are common, but in some of the large tankers plane bulkheads are favoured, particularly for the longitudinal divisions. In dry cargo ships of welded construction longitudinal framing at bottom and deck is being incorporated in many designs.

Pile Driving in Soft Ground

A New System for Increasing Resistance

On engineering works, particularly those of docks and harbours, where the ground is often abruptly variable, it sometimes happens in spite of soil investigation, that unsuspected pockets of soft ground may be encountered during actual pile driving operations. In such conditions it may be desirable for the resistance of the piles to be increased without recourse to an increase in length. Again where piles are driven in soft or medium strata practical considerations may impose restrictions on the length of piles, or the site situations and conditions may be such that normal in situ piling systems, of the expanded base type, may not be practicable.

To meet such or similar conditions a new system employing high explosive has been evolved, which invention aims at providing a simple means of increasing, to a high value, the ultimate resistance of certain types of piles.

The procedure described hereunder is more particularly suitable for reinforced concrete piles and steel box or tubular piles, though the latter two would have to be shod.

The embodiment of the invention is attained in four stages, namely:—

(i) driving a hollow pile to a certain depth;
(ii) inserting inside the pile and firing a small high explosive charge near the foot of the pile;
(iii) immediately inserting into the pile a breather pipe and pouring in a strong cement grout;
(iv) ramming the grout to fill voids in the pocket formed by the explosion and in the pile stem.
The breather pipe and ramming may or may not be necessary. This will be a matter of experiment.

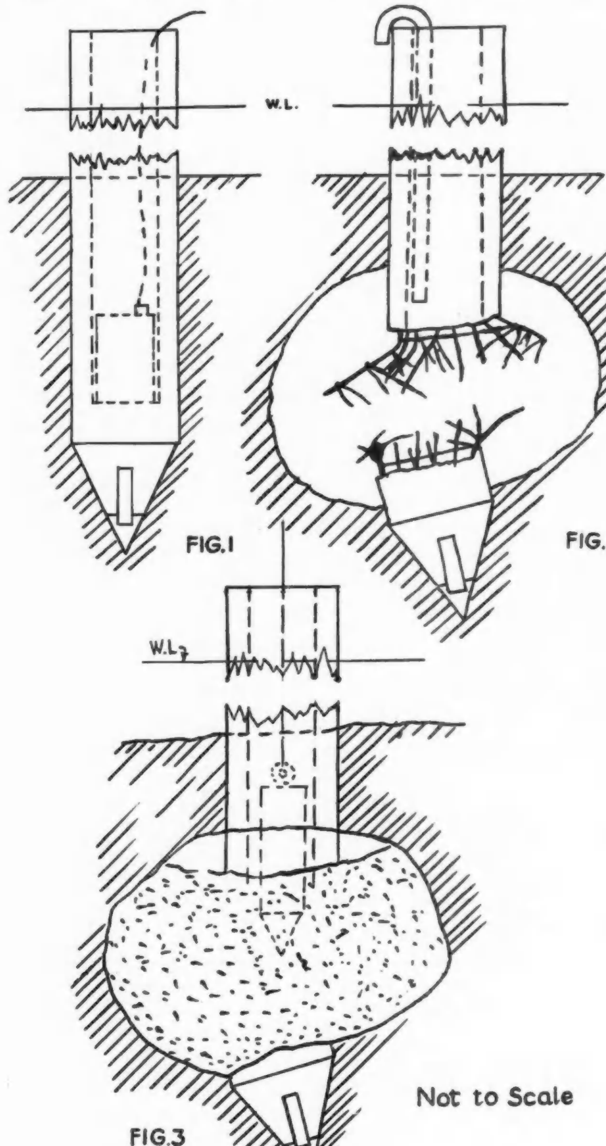
The following is a general description of the way in which the procedure is put into effect.

A hollow reinforced concrete pile is driven a suitable depth into the ground or the surface of a river bed (see Fig. 1). After driving, a small high explosive charge is placed as shown. It is advisable to insert a dummy charge first of all with exactly similar physical characteristics to ensure that there will be no difficulty in placing the live charge. The charge is shown in position in the same Figure, and may be fired by any desired method.

In Fig. 2 is shown the state of affairs which is likely to result after the explosion. Unlike low explosives, high explosives do not tend to take the line of least resistance to the same extent. Consequently the pile has been shattered and the sub-soil has been compressed before the gases escape through the pile. The breather pipe is inserted without undue delay as there may be a limit to the time the pocket is able to withstand the external forces tending to collapse it.

Fig. 3 shows the grout being rammed. The ram should be loose fitting inside the pile for ease of operation and to facilitate " breathing." The grout should preferably fill the hollow throughout the pile length. In the case of hollow steel piles, an arrangement whereby reinforcement could be inserted inside the pile before the grout is desirable, as the question of corrosion of the outer steel work would then diminish in importance.

After a stipulated interval of time the pile is ready to take its full load. It should be noted that the bearing resistance of this type of pile is not only increased because of the additional area of its foot, but also by virtue of the fact that all the bearing area on the



foot has been consolidated by compression at extremely high pressure.

It is also pointed out that in certain cases and after a suitable interval of time, the operation described above could be repeated on the same pile, at a higher level. The amount of high exposive can be determined by making reference to the set of the pile. All piles can be driven in the normal way in the first place, and converted to conform to this invention, as may be found necessary afterwards. Thus, by dividing the piling into two operations, i.e. (a) driving and (b) firing and grouting, great speed of construction can be attained.

Certain advantages will be apparent over cast-in-situ piles which at first sight may appear similar. The above invention is the subject of a British Patent—Specification No. 1859/53.

Corrosion and its Prevention

Practical Considerations in Maritime Engineering

By N. N. B. ORDMAN, B.Sc., A.M.I.C.E.

IT is to be expected that attention should normally be directed to the more spectacular aspects of maritime engineering such as the construction of quays and jetties, the prevention of floods, land reclamation and so on. We must not however lose sight of the prosaic but essential problems of maintenance, paramount amongst which is corrosion, its prevention and deterrence.

This problem is, of course, common to most engineering enterprises, but in our docks we frequently meet with environmental conditions which combine the corrosive properties of industrial and marine atmospheres and are thus more severe than those normally encountered. Structures which are permanently or periodically immersed (e.g. lock gates and jetty sub-structures) are special to maritime engineering and add complexity to the problem.

Corrosion and its prevention are the subjects of constant research and of a considerable literature. The nature of metallic corrosion has been revealed as electro-chemical in the main, and although the basic principles of the theory are readily understandable, the development of the theory is highly specialised. Paint technology has made giant strides in recent years and, with the development of synthetic resins, emulsions and chlorinated rubber based paints, it has withdrawn almost entirely into the esoteric sphere of the industrial chemist.

What the maintenance engineer most urgently requires is a fundamental understanding of the nature of corrosion and a comprehensive, practical guide to its inhibition or prevention.

The most excellent British Standard Code of Practice on "Painting," CP231(1952) contains a great deal of very useful information on the constitution of paints and very useful guidance as to the methods of use and the fields of application of the many different types. But, because of its very wide scope (it deals with ferrous and non-ferrous metals, timber, brick, masonry, plaster, and other materials) it cannot deal specifically with many of the problems that confront the maritime engineer. Nor does it, of course, deal with anti-corrosive measures other than painting, such as cathodic protection, metal spraying or the use of corrosion resisting alloys.

Specific Maritime Problems

What then are the specific problems of the maritime engineer? The first, of which mention has already been made, is the especially corrosive nature of the atmosphere in many dock areas. Frequently situated immediately adjacent to highly industrialised localities they are also exposed to the sea air. They thus present unusually severe cases of corrosion due to atmospheric pollution.

The variety of structures is unusually wide; jetties, quays, bridges, transit sheds, warehouses, permanent way, locomotives, cranes, cold-stores, conveyors are but some. Then there is the single but very important category—marine plant, comprising dredgers, barges, floating cranes, pontoons, tenders, launches, etc. Many dock undertakings have floating landing stages, lighthouses, beacons, buoys and moorings to add to their heavy maintenance commitments.

Many structures, because of the great expense involved in their constructions and the difficulties attendant on their replacement, must be maintained beyond what would be in other circumstances an economic life. These old structures present special maintenance difficulties.

Building Materials

The materials mainly used in structures and plant are mild steel, timber, concrete, masonry (including brickwork) and cast-iron. Secondary materials include aluminium, zinc (including its use in galvanising), lead and copper. Other materials such as asbestos cement, asphalt, tar, bitumen, slates and so on, although not in themselves liable to corrosion, are of importance either as alternatives to corrodible materials or as protective coatings.

Rust resisting steels, low-alloy steels and non-ferrous alloys (mainly aluminium alloys) are finding increasing use.

The maintenance of timber structures has been dealt with in a series of articles in this journal*. Concrete and masonry, although they present their own maintenance problems, are not subject to corrosion in the normally accepted use of the term. (Reinforced concrete, however, can provide an important example of destructive deterioration, mainly as a secondary effect of the corrosion of mild steel).

The corrosion of mild steel, widely used in the form of plates, sheeting, rolled sections, etc., constitutes the largest and costliest item of maintenance expenditure. The maintenance of "sheeted" sheds forms an important part of the total maintenance costs of many dock undertakings. Comparative costs of the various forms of sheeting (ferrous and non-ferrous), must have regard to the initial cost of supplying and erecting, subsequent maintenance costs, the life of the material, the additional cost or saving that might accrue in the structural members, and other considerations. Such costs must be used with great discretion and can only be regarded as a guide. They will be affected by the location, the scale of the work and many other features of the site and the particular work under consideration.

Sheeting

(a) Comparative Costs.

As an indication of the order of cost involved, a shed 300-ft. long by 120-ft. wide may be considered. The cost of erecting such a shed in Britain, exclusive of foundations and floors may be of the order of £27,000, of which the sheeting (18 ga. galvanised, corrugated steel) may account for somewhat less than half. Taking untreated mild steel corrugated sheeting (18 ga.) as unity, comparative costs of other forms of corrugated sheeting (supply and erect) may be taken approximately as follows:—

(a) Untreated mild steel (18 ga.)	1
(b) Asbestos cement	0.8 to 1.1
(c) Galvanised mild steel (18 ga.)	1.3
(d) Proprietary coated mild steel (22 ga.) ...	1.4
(e) Aluminium alloy (18 ga.)	1.8

Note: In cases (b) and (d) the purlin spacing will require to be less than in the other cases.

(b) Comparison of Properties.

Except in the case of temporary structures the form of sheeting to be used will not, of course, be selected solely on the grounds of first cost; the expected life and the maintenance costs during that life being an equal consideration together with the physical properties of the sheeting.

The use of types of sheeting less susceptible to corrosion than mild steel is an obvious expedient. Sheets such as asbestos-cement, zinc, aluminium alloy and plastic have been or are being used. Copper is not used for the type of buildings under consideration.

As regards strength—cost ratio all other forms of sheeting compare unfavourably with mild steel. Asbestos cement sheeting with its comparatively low initial cost and incorrodability is certainly economical in positions where its frangibility is not an important drawback. The walls of quay-side transit-sheds are not such places, and where roof sheets are vulnerable, such as at the eaves and gables, asbestos cement sheeting, if it is used, must be protected from accidental blows by quay and mobile cranes. With the growing use of mobile cranes and fork lift trucks inside sheds whereby goods may be stacked up to the eaves and higher, asbestos cement sheeting is very vulnerable. A tendency to split, certain difficulties in effecting repairs and the need to reduce purlin spacing detract from what is otherwise a clear economic advantage.

*Reference: Structural Timbers for Dock Work II, by B. Alwin Jay, Dec., 1952.

Corrosion and its Prevention—continued

It is still too early to express an opinion on the use of aluminium sheeting in ports. The material is now being given extensive trials in the Port of London. Apart from its resistance to corrosion, its relatively high strength—weight ratio gives it an advantage over steel which has, however, a higher strength—cost ratio. But aluminium alloy brings its own corrosion problems. It must not be allowed to come into contact with ferrous metals as it will tend to " sacrifice " itself to them in the ensuing electro-chemical reaction. Care must also be taken in the positioning of electricity cables, and the atmosphere in highly industrialised areas may contain chemicals which have a severe corrosive effect on the sheeting unless the particular alloy used has been carefully selected. However its lightness and the reduction in maintenance costs which may be expected if the material is properly used make for increased use in ports.

Alternative to non-ferrous sheeting is the " protected " mild steel sheet. The best known and the most widely used is galvanised " iron," i.e. mild steel dipped in molten zinc. This type of cladding is normally left untreated for a year or two and then painted at intervals as for mild steel. Theoretically if the zinc is preserved the mild steel will last indefinitely; the zinc, as well as sealing the surface, acts as an inhibitor. However, in practice, the preservation of the zinc is often neglected and galvanised sheets are expected to last without any maintenance treatment. This is a mis-use of the material. It possesses the advantage over mild steel that it does not corrode during delivery and erection and provided that the sheets receive their initial treatment at the right time and are kept painted, they will have a very long life.

Mild steel sheeting covered by a layer of bituminous coating is widely used. Now that paints are available which can successfully cover the bituminous coating it is no longer necessary to lose reflected light in a shed by having a dark ceiling. From the purely structural point of view the protective coating adds to the dead weight, and because the sheeting is protected its gauge is normally reduced to offset this additional weight. This results in closer purlin spacing. A possible disadvantage is that, should the protective coating be damaged, corrosion may be set up which would be very difficult to detect. This can be avoided by careful erection and maintenance inspections.

Cost of Painting

The order of cost of painting the sheeting only of a shed of the size instanced, sheeted with galvanised steel is about £3,000, i.e. for preparing the surfaces, one coat of primer and two finishing coats; the total area, externally and internally being about 1,000 squares. The cost will vary by about ten per cent. up or down, depending on the type of paint used. An overall variation of 20 per cent. is not great and the correct choice of painting process is therefore very important. Each maintenance engineer will have formed his own preference based on his experience but such experience will of necessity be limited. There is a clear need for authoritative recommendations based on systematic observations over a long period and covering a wide range of materials and conditions. Collecting the necessary data for a large variety of structures, conditions and initial and maintenance treatments is a formidable task, as is the correct and unbiased evaluation of the results. There appears to be no doubt, however, that it would be rewarded by a considerable national saving in unproductive expenditure.

Structural Steelwork

The structural members of transit-sheds present comparatively little difficulty as they are mainly protected, and compared to the sheeting their area is small.

The corrosion of structural members (almost invariably steel) is of great importance in such cases as bridges, cranes, lifts, and plant of many types. Here the one-time reliance on " wire brush, one coat of red lead and two coats of genuine lead paint " appears to be wavering. The recently developed techniques of flame cleaning, sand or grit blasting, phosphating, metal spraying, etc., demand attention, and graphite, micaceous iron ore, aluminium, chlorinated rubber and other paints all appear worthy of a trial. The number of permutations of initial and subsequent treatments is large, but far more bewildering and numerous are the claims in the advertising literature of paint manufacturers whose number appears to be legion.

Fortunately a number of helpful papers have been published, although, naturally, some of the average costs given vary with the experience of the compiler.

The subject can be considered in two parts; initial treatment and subsequent maintenance treatments. Initial treatment does not present many practical difficulties once good grounds have been established for deciding on a particular treatment, provided that the fabricating workshop has the necessary equipment. The possibilities regarding maintenance treatment are so numerous, that here again expert advice based on extensive experience is frequently called for.

Where the cost of the initial treatment is high and maintenance treatment low, the economic advantage as compared with low cost initial treatment and high cost maintenance treatment will increase with the life of the structure. Fifty years is frequently taken as a criterion. But the rapidity of modern progress makes it doubtful in some cases whether a structure does not become obsolete for operational reasons after a much shorter period. This raises the important question as to whether there is not a tendency in this country to build too well, that is to design certain classes of buildings with greater strengths and longer lives than are called for on purely functional grounds. This is a large question, outside the scope of this article, but it has an important bearing on the initial and maintenance treatments of steel buildings.

Before and during erection there are, of course, no difficulties regarding availability of the site or accessibility to the structural members. The inconvenience and expense of taking structures or plant out of service for maintenance is a serious factor, and one frequently neglected in an assessment of maintenance costs. If the interval between treatments can be increased from say three, to seven years, the reduced interruption to operations may render it more economical to adopt a treatment which is in itself more expensive. In dealing with plant, particularly mobile plant, allowance is normally made for a certain number of units to be out of commission for maintenance. This does not apply to warehouses, transit-sheds, cold stores, etc. The function of dock undertakings is to handle cargoes as efficiently and rapidly as possible, and the operating personnel can hardly be blamed if they consider the activities of the dock engineer, particularly as far as maintenance is concerned, as costly (though unfortunately necessary) interruptions to normal operating.

Practical Maintenance Difficulties

The engineer must " work-in " with his operating colleagues in as unobtrusive a manner as possible. This raises three considerations:—

(a) The initial and maintenance treatments must be such that the intervals between treatments are as long as possible.
(b) It may be economical, bearing in mind the " planned " life of the structure, to permit some corrosion.
(c) Maintenance treatment must be carried out when it is convenient to the operating departments and not when conditions are most suitable for the treatment.

Consideration (a) has been discussed above. The second consideration is of far reaching practical importance and is, in fact, common practice. It implies a waste of steel, but having regard to difficulties and sometimes the practical impossibility of access it is sometimes a necessary precaution.

The third consideration is most significant. The importance of adequate surface preparation prior to painting is frequently stressed and is generally appreciated. The surface must be dry, free from dirt, rust and scale and have a suitable finish to take paint. While these requirements can be adequately met in laboratory and workshop, they are frequently not even approached under site conditions. A large part of the initial treatment can often be carried out in the shops before delivery to the site, but subsequent treatment and in particular maintenance painting must be carried out when the structure can be made available and it is most unusual, in this country, for that to coincide with a long dry period!

While it is appreciated that metal surfaces can be adequately protected if they are suitably prepared and covered by a continuous, tough and elastic paint or metal film, there is undoubtedly a great need for a reliable and tested treatment that can be applied to surfaces not so prepared and that will inhibit corrosion where

Corrosion and its Prevention—continued

it has commenced and prevent further attacks. There are on the market proprietary materials which, it is claimed, "can be painted over rust," and will provide the protection required, but, so far as the author is aware, results of long duration tests by disinterested bodies have not yet been published.

Submerged Structures

There are certain structures which present corrosion problems special to maritime engineering. Examples of these are steel jetties, steel sheet pile structures, lock gates, floating landing stages and craft of all kinds. These can be divided into three main categories: those which are invariably submerged wholly or in part; those which are periodically submerged by tidal action; and those belonging to the above categories but which can be dried out for maintenance at intervals ranging from one to twenty years. Many types of coating have been tried, and other anti-corrosion treatments such as cathodic protection, and the use of corrosion resistant steel alloys are being increasingly used. Very valuable research into these questions has been and is being carried out by the Sea-Action Committee of the Institution of Civil Engineers, the Corrosion Committee of the Iron and Steel Institute, and other research bodies in this country. In the case of sheet piling and jetties where parts of the structure are invariably submerged the choice would appear to lie between the provision of sections with a margin to allow for wastage by corrosion, the use of steel alloys resistant to corrosion, cathodic protection, or encasement of the steel members with an inert material such as concrete. Comprehensive comparisons of the adequacy and costs of these methods would give most useful guidance.

Interior Decoration

An important aspect of maintenance painting is that which deals with decoration and hygiene. Many buildings in docks are subject to the requirements of the Factories Acts, and some to special regulations regarding food storage. In addition there are administrative buildings, dwellings, canteens and other properties where the preservative aspect of painting is not the only aspect to be considered. In this field the engineer is faced with a bewildering variety of proprietary products. The British Standard Specifications are of considerable assistance but within their framework the engineer must rely largely on his own trials and observations. The advance of paint technology is so rapid that the engineer is no longer competent to judge a product by a knowledge of its constitution. He must therefore either blindly apply a standard specification, or rely on the advice of an expert who, if he is employed by a firm of paint manufacturers cannot in the nature of things be entirely unbiased.

It is not easy to see a solution to this problem but a line of approach might be the setting up of a public body (or the utilisation of an existing organisation) with the task of analysing proprietary materials, stating their approximate constitution and/or the results of tests. Such a solution would rely on the voluntary co-operation of the industry and indeed might well be initiated by the more responsible members thereof in their own interests.

Conclusion

Many aspects of the problems which arise in connection with corrosion and painting have not been dealt with in this article, in particular those which arise in tropical climates. An attempt has been made to give a general picture which, it is thought is familiar to maritime engineers. The author makes no apology for presenting this picture as he sees it. There is a great need for a rational approach to this important aspect of maintenance. Before such an approach can be adequately undertaken the problem must be clearly seen and stated.

Port Engineering Projects

Difficult Problems Resolved by British Consultants

By J. A. POSFORD, M.A., M.I.C.E.

The important role of the independent consulting engineer in the furtherance of post-war development schemes has been demonstrated many times by the successful solution of problems along unfamiliar, and sometimes unprecedented, lines. Specialist training, and wide experience of similar and allied engineering problems, coupled with an independent position regarding contracts and suppliers, have often resulted in quick and economical achievement of a project, even after various committees and councils have reached the despairing conclusion that "it can't be done."

The plethora of councils, committees, societies, and organisations established since the end of the war have done, and are doing, much useful work, but they must, of necessity, think in terms of national, or even international requirements. Development schemes evolved are often so vast that they involve engineering works to the value of millions of pounds, which must monopolise huge resources for many years if they are ever to be brought to fruition.

World-wide publicity given to the debates and decisions of these bodies is inclined to engender the attitude that some all-embracing council will eventually deal with the particular local need, and that local action is therefore unnecessary; an attitude which is a fruitful breeding ground for lethargy and inaction.

If those in authority will only disregard the defeatist advice of those whom an eminent public speaker recently described as "no-men," the independent consulting engineer may well be able to suggest an original approach to the problem. He can be relied upon to know just when to depart from the formulae laid down by the mathematicians and he possesses considerable and varied experience of general affairs as well as of the design of particular engineering structures.

An admirable illustration of this originality of approach is provided by a project carried out during the late war. The British Admiralty required a sufficient number of slipways at widely scattered points where repairs could be speedily effected to small naval craft. Conventional construction methods required 12 to 18 months for the completion of each slipway—an impossibility owing to the timing of proposed naval operations. Floating docks were suggested as a more convenient alternative, as they could be towed from place to place serving the damaged craft more effectually and with greater flexibility or operation than fixed slipways. It was pointed out, however, that at least 18 months would be required for the construction of each floating dock to the accepted pattern, using valuable shipyard space; no steel plate could be spared, and no trained shipyard labour was available.

A consulting engineer found the solution in reinforced concrete floating docks of special design. Within ten days the design was completed, and construction commenced; three months later the first completed dock floated out of its temporary construction basin.

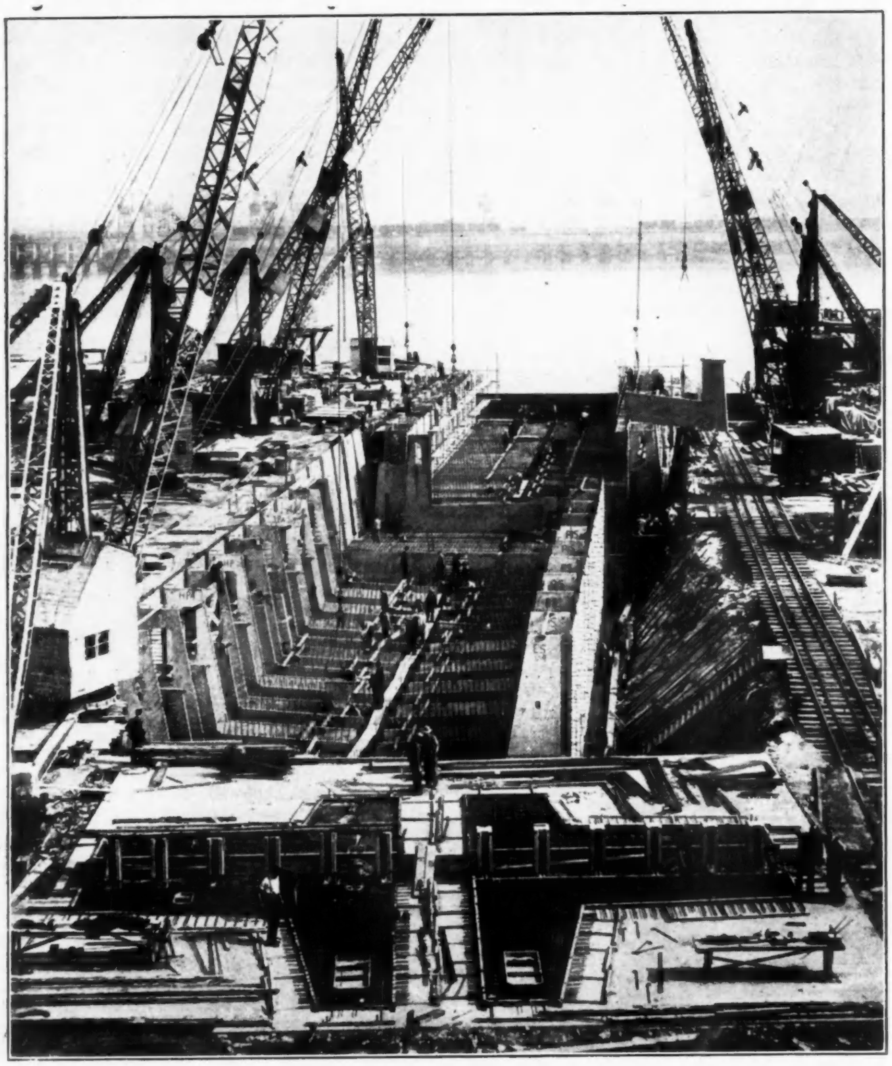
Further docks were launched from the same building basin at the rate of one every month, and eventually 52 of these units were ordered to be built. No shipyard space, materials, or labour were needed, and four building berths were ordered to be set up—two in the United Kingdom, one in India, and one in Australia. The standard heavy beam and slab type of reinforced concrete construction was dispensed with in favour of a thin pre-cast slab technique, and this formed the essential basis of the design. Greater flexibility in the structure, and speed of construction was thus assured.

The vertical walls and the ribs were precast in stacks, one on top of the other at 24-hour intervals, then lifted up by derricks and assembled like a house of cards. The slabs themselves were 4-in. thick and assembly took two days for each dock. The 5-in. thick bottom floor of the dock and the decks were then concreted in situ, immediately the vertical splice joints between the slabs had been concreted. These joints, into which projected the reinforcement from the slabs on each side, were concreted in one lift, sometimes 30-ft. in height, on the principle of a slide fastener.

Port Engineering Projects—continued

Two diesel pumps housed in one of the walls served to work the dock up and down in the water, and for trimming the ballast tanks to suit the load distribution imposed by the weight and position of the various types of ships lifted.

These docks were towed to Normandy and the Mediterranean and some even all the way from Britain to Singapore, without developing leaks or otherwise giving trouble. For constructional speed and simplicity, these floating docks compare with the Liberty ships built in the U.S.A., and responsible American officials were greatly impressed by their performance. In an official publication concerned with their own production of reinforced concrete docks they recommended the exclusive use of this British design for any future projects.



Two Reinforced Concrete Floating Docks under simultaneous construction in one building berth. A pair can be constructeed in four weeks.

This type of reinforced concrete floating dock can be built almost anywhere, compares favourable in cost with a steel dock, can easily be moved from port to port, and requires virtually no maintenance at all. It is all the more surprising, therefore, that no permanent use has been found for them in various parts of the Commonwealth, the member countries of which own over 20 million tons of merchant shipping.

The same type of construction could well be used in connection with the berthing of flying boats. Development of the giant 10-engined Saunders-Roe S.R. 45 Princess flying boats is now nearly complete, but indecision prevails regarding the use of these aircraft on Empire routes. It has been suggested that "the State should provide the flying boat's port equipment," but surely it would not be impossible for a number or ports on a route each to supply its own facilities for these aircraft? The S.R. 45 Princess, the largest flying boat in the world, has often been shown in Press photographs standing upon the apron and piled slipway adjacent to the assembly hangar at its home port of Cowes. The apron and slipway are reported to have been specially rebuilt for this aircraft at a cost of £45,000, which is not an unduly large figure. These necessary facilities could be provided locally out of local funds and reimbursed in due course from landing fees. A state of suspended animation, however, still persists, pending action by State organisations.

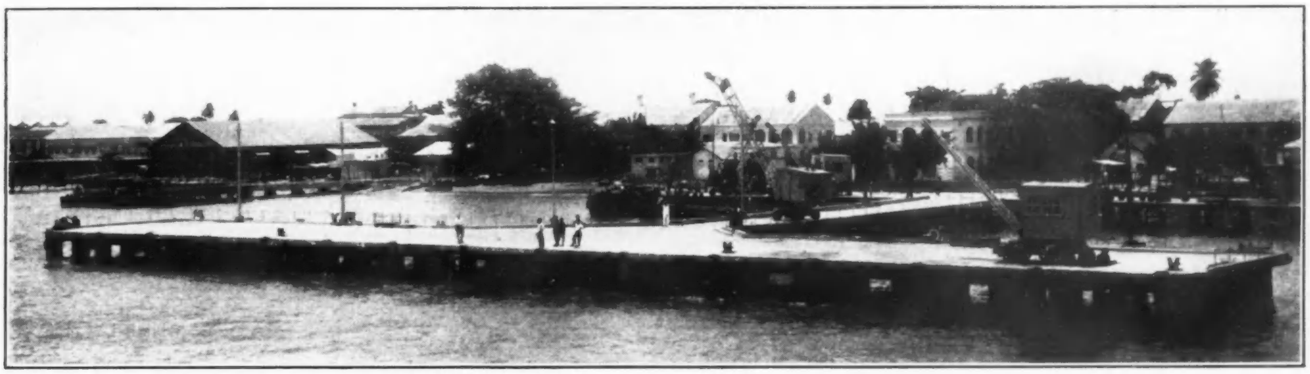
A recent example of enlightened local action was the decision of the then Governor of Gambia to provide, at Bathurst, facilities for the berthing of the largest ships that can enter the Gambia River. This project had to be financed out of local funds, which were severely limited, and advice was sought from a consulting engineer, who, in association with the Governor and local officials, worked out a satisfactory solution. The sum of money available—£85,000—was modest for this class of construction, even under ideal conditions in an area where all the basic materials are readily available. In this instance, however, the Colony could offer no steel, cement, suitable timber or suitable stone or gravel, out of which to manufacture good quality concrete; nor were there available any commercial workshops. The current in the river estuary at Bathurst is fierce, and, although the water is normally fairly smooth, tornadoes are encountered at certain times of the year. There is also no firm land in the vicinity, all the subsoil for a great depth consisting of very fine mud and silt.

Special measures had to be taken to overcome all these difficulties and unpromising conditions. Most important was the designing of a special type of pile upon which to support the wharf. These piles were of reinforced concrete, cylindrical in form, with an outside diameter of 3-ft. and an inside diameter of 2-ft. 4-in.; 75-ft. long, and weighing 15 tons each. Each pile was cast at the site in three 25-ft. sections, these sections being cast in one single lift with the axis of the cylinder vertical. The sections were then laid end to end on the foreshore with their axes horizontal, and joined together to form one complete 75-ft. pile. At one end they were fitted with a solid concrete point; the other end was temporarily sealed by a watertight iron plate.

The whole pile was then rolled into the river, where it floated with the assistance of two floats made of pairs of drums, and towed to the position of the wharf. One of the floats was then loosened to allow the heavy concrete point to sink to the river bed, and its other end lifted by means of a light winch and tower, mounted on a pontoon. The pile being half in and half out of the water, only half the full weight of the pile had to be supported. Driving of the pile was carried out partly by water jetting and partly by the use of a special solid cylindrical hammer operating inside the hollow pile, the blows being delivered at the toe.

All the piles, whether vertical or raking, were thus simply and effectively driven 35-ft. into the soft mud. Each pile could carry 50 tons by virtue of its large size, which not only provided an area of 7 sq. ft. directly bearing upon the silt but also provided an area of 350-ft. sq. ft. of side surface to take frictional support from the

Port Engineering Projects—continued



The completed Government Wharf at Bathurst, capable of berthing the largest ships entering The Gambia.

penetrated strata.

The concrete deck of the wharf was then constructed, the main supporting beams being pre-cast and connected into the heads of the piles. No underwater bracing was necessary, as the tubular form of the piles gave these great strength over the 45-ft. long unsupported length between the point of firm embedment in the river bed and the underside of the deck.

The completed wharf was T-shaped in plan, the tail of the T being connected to the shore, and the head, which comes into contact with the midship section of the berthing vessel, being 219-ft. in length. Adequate facilities are thus provided for discharging cargo from two holds at the same time. Two isolated dolphins, in line with the T head and some distance from each end, provide bow and stern moorings for the ships. Design and construction of this wharf was planned to ensure that the minimum of materials and plant had to be imported into the Colony, and every possible use was made of the natural conditions of the site. In certain respects normal text-book theories and practices were disregarded in the interests of economy, simplicity, and speed of construction. This can safely be done in specific instances and by experienced engineers, but it cannot be advocated by a distant committee for wholesale application. Bathurst now possesses a fine modern wharf with first-class berthing facilities, all provided for the modest sum of £85,000.

Occasionally the development of a finely conceived project has been held up because of a wrong assessment of the cost or time for construction, these having been based on an apparently similar, and uncostly enterprise. It can be very misleading to follow precedent too closely, for no two sites are exactly alike, and a comparatively slight variation in conditions may make all the difference between an economic and uneconomic proposition. The instances quoted in this article are indicative of the achievements of British engineers in many parts of the world ; time and again, not only in port works but in all branches of civil engineering, most unpromising circumstances have been successfully overcome by the experts trained to this task.

The Consulting Engineers for all the projects mentioned above were Messrs. Maunsell, Posford and Pavry of Abbey House, Westminster, S.W.1, who are also members of the Association of Consulting Engineers, 36, Victoria Street, London, S.W.1 This Association can be relied upon at any time to recommend experts from their membership who can give the necessary advice and guidance on any kind of civil engineering project in any part of the world.

Repairing Concrete Piles

The satisfactory repair of deteriorated concrete piles is developing into a major problem in many localities where bridge and dock facilities have been exposed to the weather for a period of 20 years and longer. Alternate freezing and thawing, chemical action and probably other causes, little known at the time of construction, result in necking and disintegration of concrete piles between the high and low tide levels. The immediate effect of these actions is a decrease in the effective section of the pile and rusting of the reinforcement, and over a long period of time, this deterioration can result in a failure of the structure. The Masonry Resurfacing and Construction Company, Inc. of Curtis Bay, Maryland, U.S.A., has therefore developed the " Dri-Por " system of pile reintegration which restores the pile to its original section and gives it additional protection. It is claimed that the new system utilises unique equipment and techniques which are superior to many other methods now in vogue.

Deterioration usually occurs only between mean low and mean high water, since the forces that create disintegration have their major influence only within this critical area. Past experience has shown that above and below these limits the pile section is usually unaffected and so remains full size. In addition, the degree of disintegration varies from a slight decrease in section to a point where no concrete can be seen for several feet of pile. If the steel reinforcement has rusted away, the effectiveness of the pile in the latter case is nil. When carrying out repairs, therefore, the essential idea is to encase only that section of pile which has deteriorated and not the entire pile, and most methods now follow this procedure.

Because the area of deterioration is mostly below water, it is usual in ordinary methods to employ a diver to clean the pile of all marine growths and to remove disintegrated concrete. It is fairly obvious that the efficiency of this type of operation is impaired by the bulkiness of the diver's equipment and his inability to see what he is doing, especially in the polluted waters of our present day harbours. In addition, the diver cannot investigate the state of deterioration carefully, a procedure which is necessary to provide a satisfactory repair. The result often is that the pile is not cleaned sufficiently to enable the new jacket to bond successfully to the old concrete.

After the pile is chipped, mesh is usually placed around the pile and a form is set. The form is then sealed and dewatered, after which the concrete is poured. It is also within the realm of possibility to " tremie " the concrete. These procedures, at best, can guarantee only a mediocre job since it is virtually impossible economically to eliminate all water from the form.

Generally speaking, most methods for pile encasement are variations of the method described above, and there are many possibilities for indifferent workmanship with consequent weakness in the repair. One drawback that must be taken into consideration is the effect of water pollution on the repair. Should there be any lapse of time between the time the pile is chipped and the concrete finally poured, it is quite possible that the rising and lowering of tide levels will leave a film of scum, oil or other material on the recently cleaned area, with the result that the bonding qualities of the new jacket will be seriously affected.

The " Dri-Por " system follows the older

Repairing Concrete Piles—continued

Chipping and preparation of pile, within the caisson.

methods in so far as the various steps involved are concerned, however, the differences come in technique and procedure. At no time is the work done " blind "; neither can oil or scum contaminate a pile, and still go uncorrected.

This system embodies an open-topped caisson which is specially designed to acccommodate a pile and a man to work on the pile. The caisson is so sealed that little or no water can enter around the pile from the outside. After setting the caisson, it is pumped dry so that very little water remains on the floor of the caisson. If water should seep into the caisson, the pump is run continuously keeping the working area dry at all times.

After the caisson is dry, the area of deterioration of the pile can be seen and necessary work begun. A man enters the caisson and begins chipping away the eroded concrete. The concrete is chipped until the remaining concrete is hard and clean. If it is necessary to cut behind the reinforcing rods and even completely through the pile, this is done.

When chipping is completed, the condition of the reinforcing is appraised and if necessary, repaired or replaced. Wire mesh is then anchored to the pile to further strengthen and improve the repair.

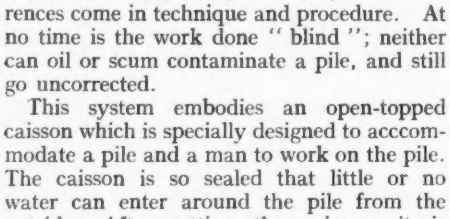
The pile is now ready for its permanent form which is next placed about the pile. This form is set independent of the caisson and at no time touches the floor of the caisson, so that any movement of the caisson itself will not disturb the concrete in the form. In addition, any leakage in the caisson will not wash out concrete at the

2. Inhibition of deterioration and decay, with the reinforcing rods therefore protected for a longer period of time.
3. Use of a durable concrete able to withstand longer cycles of alternate freezing and thawing.

In other words, the man working on the pile sees what he is doing; sees to what extent deteriorated concrete has to be removed; sees the condition of the reinforcing rods. He also works on the piles as if they were on dry land, and, in addition, there is no guess work as to whether the deteriorated concrete and various encrustations are thoroughly removed. He makes the necessary inspections to ascertain the degree of repair and also can be checked in his conclusions by an inspector. Under these conditions, the concrete encasement is certain to bond to a clean, solid concrete surface; also reinforcing rods can be cleaned and replaced wherever necessary.

The second result, inhibition of decay, is

"Dri-Por" pile encasements, pile tops and capping beam prepared for " Gunite " repairs.



Placing the reinforcing mesh prior to placing the form and pouring the concrete.

bottom of the repair, since the encasement is at least 6-in. from the caisson floor.

The form is fastened to prevent movement in any direction and is then filled with concrete. There is no lapse of time between chipping and forming and final pouring of the concrete and during all these operations the pile is dry. The final step in the system is the " Gunite " repair of all the pile above the encasement. This work is usually started after sufficient piles have been encased to make the operation feasibly economical, to provide a better looking job and to help protect the pile encasement. The repair consists of chipping the exposed pile, placing mesh and shooting " Gunite " to the lines of the pile encasement.

The " Dri-Por " system eliminates many drawbacks of older methods and provides positive control in all stages of repair, and the following results are therefore obtained :

1. Good bond between old and new concrete so the repair will remain in place and become an integral part of the pile.

obtained in several ways. First, the original pile section is enlarged several inches for the length of the repair. This immediately provides an extra layer of concrete around the pile at its most vulnerable area. In addition, the concrete is poured into a metal form which remains in place permanently. Before deterioration can reach the original dimensions of the pile, the galvanised form and the additional thickness of concrete must be worn away. It is fairly obvious that the life of the repair is lengthened by the adoption of the above procedures, the actual length of time depending on local conditions.

The last result, a durable concrete, is obtained using a high cement factor plus the addition of an air-entraining agent.

The " Dri-Por " system has many advantages to recommend it and the only limitations are those of space, that is, the piles in the structure may be too close together to allow the smallest caisson to fit or the piles are in clusters of such proximity that the caissons cannot be manœuvred into position.

Fendering, Lead-in Jetties and Dolphins

High Work Absorbing Capacity of Conventional Types

By A. M. ROBERTSON, A.M.I.C.E., A.M.I.Struct.E.

Introduction.

ALTHOUGH improvements have been made in recent years in the design of fendering for very large vessels and special conditions, most of the devices developed are unsuitable for general purpose wharfs and jetties, and it would appear that a more conventional type of fendering has many advantages and will continue to be used for these berths for some time to come.

The purpose of this article is to present the basic data for the design of fendering for general purpose berths, lead-in jetties and dolphins, to show that a simple conventional type of fendering has a high work absorbing capacity, and to indicate possible improvements. The essential requirements of a general purpose berth is that both wall-sided and belted vessels can come alongside. This rules out the usual type of floating fender as a permanent feature, although most port authorities will, when dealing with large vessels supply floating fenders.

By far the most important objectives in designing fendering are long life and low maintenance costs. This means restricting the impact loads on the fendering and to do this there must be appreciable movement of the fendering. This factor will be referred to later.

When the last war broke out the development of the raker piled pier had reached a fairly advanced stage after approximately 26 years' slow development and it was this type of unbraced structure that focussed attention on the efficiency of long timber piles in bending, and showed how unnecessary and undesirable it was to design the main structures of piers and wharves to support the fender piles at close intervals.

The war-time use of steel for fendering and the shortage of suitable timber immediately after the war has, in the writer's view, greatly retarded the rational development of fendering.

The design of all engineering structures is basically a problem of selecting the material best suited to a particular case, without being influenced by propagandist literature and fashion, and it is hoped that this article will be of some assistance in this connection.

Some elementary considerations and formulæ have been included in this article for the sole purpose of presenting as complete a picture as possible for the junior engineer.

Damages to fendering of general purpose berths are more often due to forces acting parallel to the face than forces acting normally to the structure and any type of fender not capable of absorbing inclined impacts is, in the writer's opinion, unsuitable for fendering for general purposes.

Impacts.

Experience in the maintenance of fendering leads one to the conclusion that the impacts resisted per fender from large and small vessels do not differ much in magnitude, and that the belted vessel having a displacement of about 2,000 tons is more destructive than merchantmen of 20,000 tons. I will now show how this comes about.

The total kinetic energy in a moving vessel is given by the fundamental equation:

$$\frac{1}{2}\,\frac{M\,V^2}{g}$$

This in inch-tons =

$$\frac{\text{Displacement in tons} \times (\text{Velocity in feet per second})^2 \times 12}{64.4}$$

It is not certain how much of the nominal kinetic energy of a berthing ship has to be absorbed at any point of impact but it is usually assumed that when berthing a wall-sided vessel half the mass is active, i.e. half the displacement should be used in the above formula. All the larger wall-sided vessels have a considerable proportion of their length built off the same template and the resultant parallel sided hull can either make contact over a long length or near an end. When the impact takes place near an end the centre of gravity is free to continue moving and it is obvious that the whole mass cannot be acting. If on the other hand she comes in exactly parallel to the fendered face then there will be very little load acting per foot run and if the fender can resist an end coming in first they will most certainly resist an impact spread over a considerable length.

It will be seen that it is quite reasonable to assume half the mass acting in the case of a wall-sided vessel. The other type of vessel to be catered for by all general purpose berths is the belted vessel (as used for Channel and Irish ferries, etc.) which are generally much more curved on plan, some to the extent of having com-

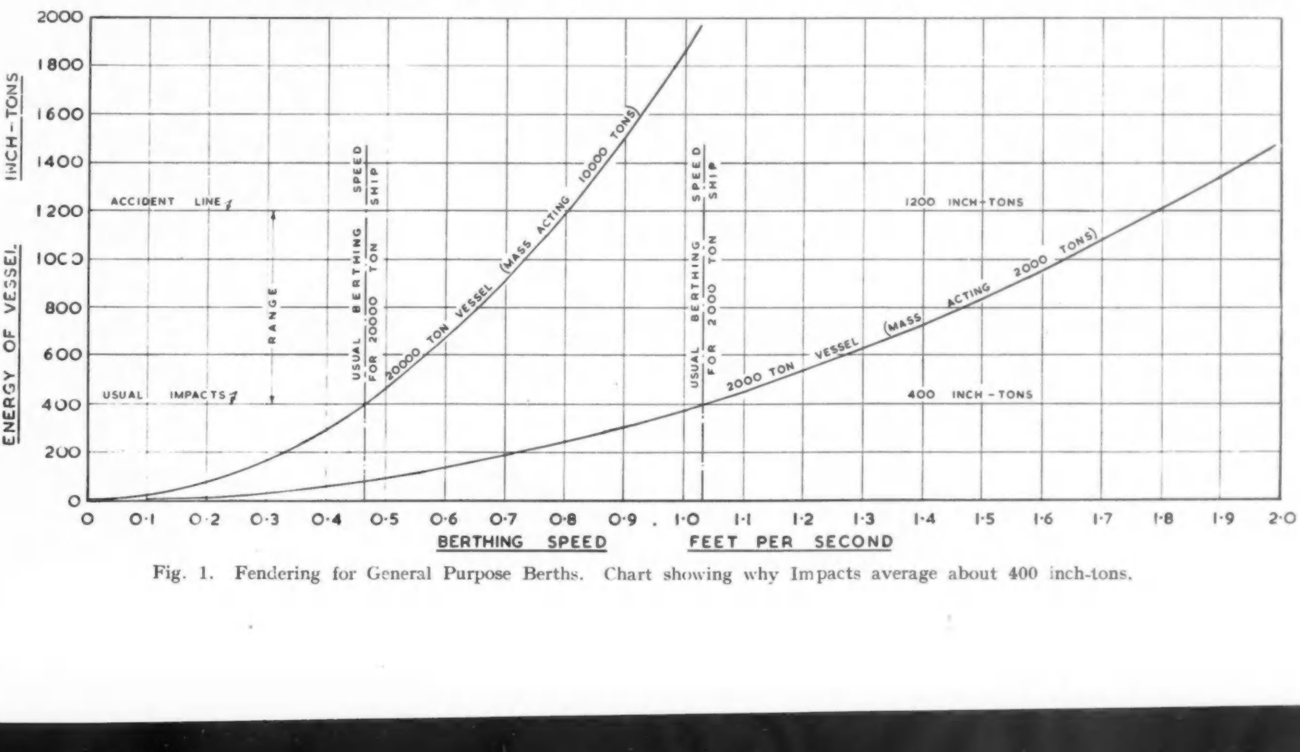


Fig. 1. Fendering for General Purpose Berths. Chart showing why Impacts average about 400 inch-tons.

Fendering, Lead-in Jetties and Dolphins—continued

pletely curved beltings capable of transmitting the whole impact as a point load, on a rigid face.

Further, these vessels are very robust and can resist a far greater local load than a wall-sided vessel before they commence absorbing work by plastic deformation. In consequence the belted vessel on impact may not only make contact in such a way as to transmit the full kinetic energy into the fendering but it constantly berths at a much higher speed and is in fact the most destructive type of ship harbour and pier authorities have to cater for.

From records compiled by Mr. Minikin through the good offices of the "Dock and Harbour Authority" and personal observation, the author is of the opinion that large wall-sided vessels berth at under 0.5-ft. per second while belted vessels berth at a velocity around 1-ft. per second.

Summing up, the kinetic energy of vessels cannot be ascertained by one rule, but by one for the belted and one for the large wall-sided ships.

In other words:—

The approximate kinetic energy in inch-tons of a wall-sided vessel

$$= \frac{\frac{1}{2} \text{ displacement in tons} \times 0.46^2 \times 12}{64.4}$$

The approximate kinetic energy in inch-tons of a belted vessel

$$= \frac{\text{displacement in tons} \times 1.03^2 \times 12}{64.4}$$

By applying these to a 20,000 ton wall-sided vessel and a 2,000 ton belted vessel it will be seen that both produce impacts in the order of 400 inch-tons. This is shown graphically in Fig. 1 and agrees with what one finds from experience. In short, it is reasonable to design a general purpose berth to resist normal impacts of 400 inch-tons. This does not apply to corners or berths made up of dolphins.

As impacts are in proportion to the velocity^2 it will be readily appreciated that a small increase in the berthing speed will greatly increase the kinetic energy of the vessel and that it is out of the question to design fendering to withstand all impacts. Somewhere, an accident line must be drawn and it is believed that for general purpose berths this should be around 1,200 inch-tons, as indicated in Fig. 1.

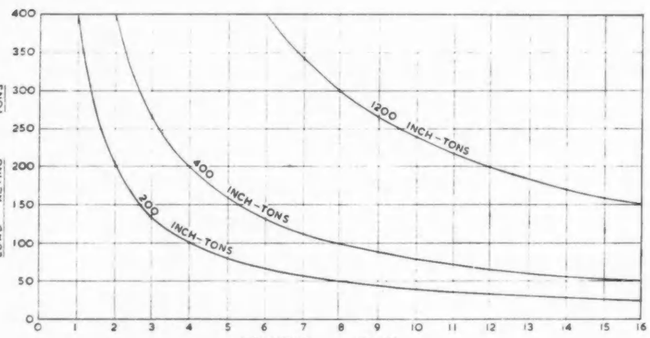


Fig. 2 Relation between Movement and Load for Impacts of 200, 400 and 1200 inch-tons.

Absorption of Impacts.

The work or energy of a moving vessel is absorbed on impact with a marine structure by all or some of the following means:—

(1) By bending of the structural members including the fendering.
(2) By deformation of a floating fender.
(3) By compressing springs or moving other mechanical or gravity devices.
(4) By elastic deformation of the vessel.
(5) By rolling of the vessel.
(6) By rotation of the vessel on plan.
(7) By displacement of water between quay and vessel.
(8) By elastic deformation of the ground.
(9) By plastic deformation of the ship's hull.
(10) By denting beltings.
(11) By the ship biting into the structure.
(12) By the bow cutting into the structure.

Engineers and ships' masters alike endeavour to avoid the last four means of absorbing the energy of impact, but these three undoubtedly form a convenient and in most cases a high factor of safety against total collapse and have saved many a main structure from destruction. The large number of dents on the hulls of merchant ships bears this out.

It is therefore a dangerous procedure to cut down the static resistance of a pier or jetty and arrange for large travel springs or such devices which may be missed completely by a vessel on impact. If the static resistance and mass of a structure is sufficient to dent the hull of a vessel this extra strength is a great factor of safety or insurance against a total collapse. The R.C. braced jetty in the Thames* would not have been pushed over had it a higher static resistance.

The ideal marine structure is one that will take a normal berthing impact with low loads acting but should the accident limit (1,200 inch-tons) be approached the static load should increase to a figure sufficient to cause plastic deformation of the hull.

It is necessary also at exposed berths to absorb work from the vessel once she is berthed. The writer knows of a case where a large ship was seriously damaged and had to be repiated over an extensive area after lying one week-end bumping against rather rigid fendering. Other cases are known where the crews of vessels found it impossible to sleep at night when berthed alongside jetties which had been reconstructed and provided with well-supported stiff fenders. Originally the whole jetties were built in timber and no such trouble arose. Much working time is lost at certain exposed piers due to vessels having to cast off to avoid damaging themselves against over rigid structures.

It is true that a rectangular member in direct stress will absorb nine times as much work as the same member in bending, but in actual practise however no one has yet managed to devise a general purpose jetty or pier to take full advantage of this fact and the absorption of work by bending is still a far more economical solution than the aborption of work by direct stress.

The weight of all fenders and fendering devices set in motion at impact is small in relation to the weight of the vessels resisted and consequently it is reasonable to equate the usual impacts to the work absorbed by the fendering without any deduction for loss of kinetic energy on impact, on the assumption that the vessels themselves absorb none of the impact.

It has been inferred by some writers on fendering that good springs are the acme of good fendering but in the writer's opinion long fender piles or similar members should receive first consideration and springs should be added at deck level only to keep the load from high level impacts within the desired limit and to increase the capacity. If high level and severe impacts are not to be expected and the fender piles are long, springs serve very little purpose when good fender piles are used.

Isolated fender piles, i.e. piles not supported by their neighbours in any way are of little use as reference to Fig. 3 will show.

Importance of Movement.

Fig. 2 shows the relation between load and movement for impacts of 200, 400 and 1,200 inch-tons, from which it will be readily appreciated that without a movement of approximately eight inches the timber facings and hulls of the vessels will be subjected to too high a load, and will crush and involve the owners in continual high maintenance charges. This observation is particularly applicable to the rubbing pieces usually provided on fenders. For example, take the case of a belted vessel of 2,000 tons berthing at 1.03-ft. per second giving a kinetic energy of 400 inch-tons and making contact on, say, three fenders. The total contact area will be approximately 280 square inches and assuming that the bearing-resistance of rubbing pieces is only 600 lbs. per square inch, then the load must be restricted to something a little under 75 tons to prevent crushing of the facings. Referring to Fig. 2, it will be seen that to restrict the load to this limit a movement of 10-in. is required.

The spread of this load from the larger vessels will be much better and where floating fenders are used as they would be for all really large vessels, the bearing stresses will be well within safe limits.

*Concrete and Constructional Engineering, January 1934.

Fendering, Lead-in Jetties and Dolphins—continued

The 200 inch-tons curve is intended to cover vessels of approximately 1,000 tons while the 400 inch-tons curve is intended to cover any vessel in the range 2,000 to 20,000 tons. The 1,200 inch-tons curve is intended to show the conditions when an out-of-control or accidental berthing takes place.

Fig. 2 is based on the assumption that the load on impact rises from zero to the maximum in a straight line and that the work absorbed equals the area of the triangular diagram, namely,

$$\frac{\text{load X movement}}{2}$$

Movement tends to allow the fendering to recede from a glancing blow and prevents destructive drag forces being applied in many cases.

Work Absorbed by Members in Bending.

The work absorbed by members in bending when subjected to the bending moments shown for Cases 1, 2 and 3 in Fig. 3, is given by:—

$$\frac{M^2\ L}{6\ EI}$$

Where M = Resistance moment of section
and L = Length of member.
E = Young's modulus of elasticity
I = Moment of inertia of section about plane of bending.

Where a member has a simple square section the work absorbed can be written as:

$$\frac{ALf^2}{18E} \text{ or } \frac{Vf2}{18E}$$

Where A = area of section
V = volume of member
and f = stress.

In other words the work absorbed in the usual cases (1, 2 and 3) is:

(a) Directly proportional to f^2
(b) Directly proportional to the length of the member, i.e. the longer the member the better, and this applies to fender piles and legs of dolphins and jetties.

This clearly indicates the importance of using members with a high resistance moment and that any small additional stress is very valuable.

Further, the work absorbed in Case 2 (Fig. 3) is independent of the location of impact provided always that the shear resistance is not exceeded. This is clear from Fig. 6.

To find the work absorbed by a particular fender pile or member in bending it is only necessary to work out the load and deflection for one point and length of member and calculate for other lengths pro rata.

As all three cases shown in Fig. 3 absorb the same amount of work for a given material and section, to find the deflection at the heads of the piles of cases 1 and 3, and anywhere between the sea bed and deck for Case 2, it is only necessary to divide the work absorbed (as given in Fig 3) by half the static load resisted at the point in question. For example, the chart (Fig. 3) shows that the work absorbed by a greenheart pile of 14-in. x 14-in. section 50-ft. long is 121 inch-tons.

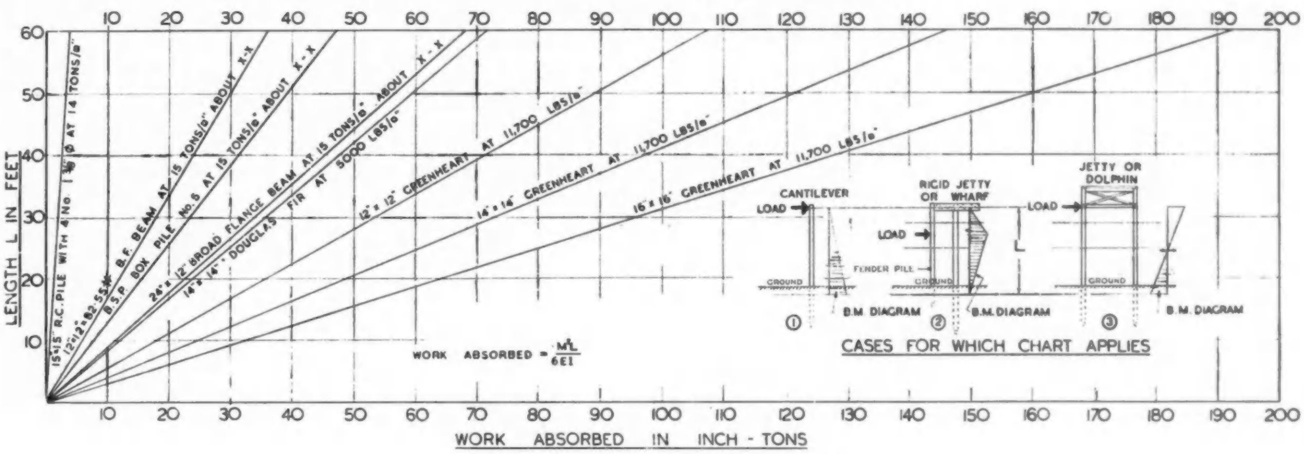


Fig 3. Work absorbed by Members in bending.

To find the deflection under a centrally applied load, it is first necessary to find this load. From Fig. 4, the R.M. is found to be 2,385 inch-tons. Therefore the central load

$$= \frac{2385 \times 2}{25 \times 12} = 15.9 \text{ tons}$$

$$\therefore \text{ Central deflection } = \frac{\text{work absorbed}}{\text{half load}} = \frac{121}{7.95} = 15.2 \text{ ins.}$$

Comparison of Work Absorbed by Structural Members in Bending.

In comparing the efficiency of members in bending for fendering purposes, three factors must be considered, namely:—

(a) The work absorbing capacity.
(b) The deflection.
(c) The static resistance.

The higher the better applies to all three, but it is undesirable to have a high work absorbing capacity obtained from a very high load and relatively small deflection or by having a very large deflection with a very small load. Fig. 3 shows the work absorbed by a variety of members in bending and the information given applies to cantilevers, simply supported members and members

Member	Resistance Moment Inch-Tons	Stress Used
24-in. x 12-in. broad flanged beam	6070	15 tons per sq. in.
16-in. x 16-in. greenheart ...	3560	11,700 lbs. per sq. in.
B.S.P. box pile No. 5	2700	15 tons per sq. in.
14-in. x 14-in. greenheart ...	2385	11,700 lbs. per sq. in.
18-in. x 12-in. x 100 lbs. broad flanged beam	2250	15 tons per sq. in.
12-in. x 12-in. x 82.55 lbs. broad flanged beam	1630	15 tons per sq. in.
12-in. x 12-in. greenheart ...	1500	11,700 lbs. per sq. in.
B.S.P. box pile No. 3	1220	15 tons per sq. in.
14-in. x 14-in. Oregon pine ...	1020	5,000 lbs. per sq. in.
14-in. x 14-in. prestressed concrete pile	720	Ultimate
16-in. x 16-in. R.C. pile (with 4 No. 1¼-in. dia. bars) ...	520	14 tons per sq. in. for steel
14-in. x 14-in. R.C. pile (with 4 No. 1⅜-in. dia. bars) ...	358	14 tons per sq. in. for steel
14-in. x 14-in. R.C. pile (with 4 No. 1⅛-in. dia. bars) ...	247	14 tons per sq in. for steel
12-in. x 12-in. R.C. pile (with 4 No. 1⅛-in dia. bars) ...	195	14 tons per sq. in. for steel

Fig 4. Resistance Movements of some Jetty Members.

Fendering, Lead-in Jetties and Dolphins—continued

fixed at both ends and subject to reverse bending. It is clear from this chart that greenheart working at its limit of proportionality stress of 11,700 lbs. per sq. inch is greatly superior, and when cost is taken into account, it is vastly superior to the others shown. It is believed that the load deflection characteristics of greenheart are good and that the fenders of some are not too flexible to encourage the masters of vessels to increase their berthing speeds.

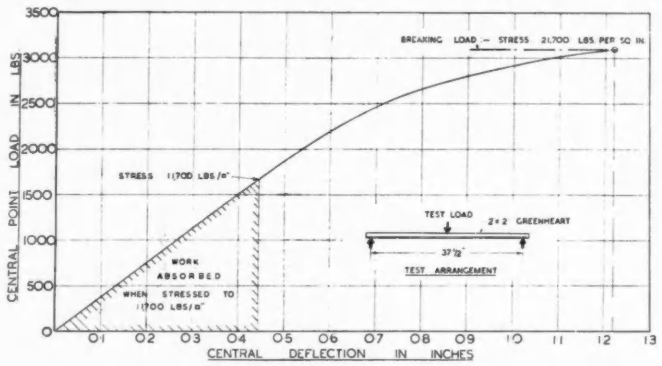


Fig. 5. Typical Load—Deflection Curve for Greenheart in bending.

It is interesting to note, in passing, that to expose the edge of the concrete dock, a good psychological effect is created on the masters of vessels, leading to careful berthing.

When members are used for the absorption of work by bending, a better spread of the load can be obtained by using fender piles of a springy material rather than by strong stiff ones.

To facilitate the determination of the deflections, Fig. 4, which shows the resistance moments of the members shown in Fig. 3, is included.

As well as a member being capable of absorbing the required degree of work, it should possess a high static resistance to get the most out of springs located at deck level and thereby produce a balanced design capable of absorbing the same amount of work at all levels.

Prestressed concrete fender piles have not been included in Fig. 3, but the ultimate R.M. of a 14-in. x 14-in. pile which has been manufactured is shown in Fig. 4. No published facts on the work absorbing capacity of these piles at failure are available but from rough calculations it would appear that greenheart possesses at least 15 times the capacity of prestressed concrete for absorbing work, and if the extra weight and difficulty of fixing is taken into account the efficiency is even greater than this figure.

In preparing Figs. 3 and 4, stresses have been selected with a view to giving a fair and reasonable comparison.

Work Absorbed by Greenheart in Bending.

The importers give the properties of greenheart under static loading as follows:—

	per sq. in.
Ultimate stress at failure in bending	19,300 lbs.
Stress in bending at limit of proportionality ...	11,700 lbs.
Modulus of elasticity	3,010,000 lbs.
Shear parallel to grain	1,290 lbs.
Compression perpendicular to grain	1,980 lbs.
Compression parallel to grain	10,500 lbs.

A typical load-deflection curve for greenheart is shown in Fig. 5. The area below the curve is the potential work diagram, and the shaded area shows the work done when a stress of 11,700 lbs. per sq. inch is reached. It will be seen that this shaded area is approximately 1/5th of the work area available before fracture takes place. In other words with a sound log the work absorbed before failure is five times that of the work absorbed when stressed to 11,700 lbs. per sq. inch. Referring to Fig. 1, it will be seen that greenheart fenders constructed of sound logs and designed to resist an impact of 400 inch-tons with a stress of 11,700 lbs. per sq. inch will cope with accidental impacts in the order of 1,200 inch-tons before fracture. The writer's experience is that a stress of 11,700 lbs. per sq. inch is fully justified as a basis of designing on the assumptions outlined above. It is well known on the lower Clyde where there are relatively exposed wharfs and piers that it is a waste of time to use softwood face or fender piles as they break very readily while greenheart has a very long life and many of the piles have been in use for over 70 years. This clearly shows that in many piers and wharfs of the Clydeside greenheart is working at a stress above the breaking stress of Douglas fir, that is, above 8,000 lbs. per sq. inch, and that the greenheart's success in this role is wholly dependent on the high breaking stress.

An analysis of the impacts from paddle steamers, where the whole impact is often transmitted through one face pile also indicates that the success and long life of the many greenheart piers along the Clyde Estuary is due to the high bending resistance of greenheart.

Fig. 6 shows the loads acting at any position on a log of 40-ft. span when stressed to 11,700 lbs. per sq. inch. This shows that where loads have to be resisted near the supports, i.e., where there is a small freeboard or where belted vessels have to be catered for some spring is required at the heads to keep the load down and reduce maintenance costs, and to avoid overstressing the logs in shear, and in the case of a jetty or pier, reduce the static load to be resisted by the main structure.

Comparison of Dolphins.

Fig. 7 shows a comparison of greenheart and steel piles when used for a piled dolphin. In this particular case at the stresses

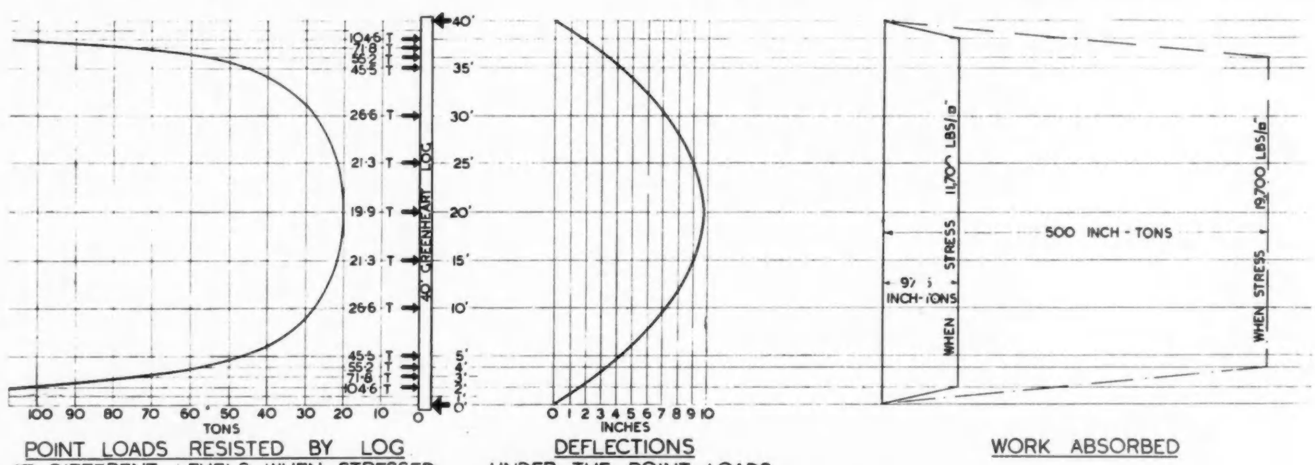


Fig. 6. Loads Resisted and Work Absorbed by 14-in. x 14-in. Greenheart log 40-ft. long, when simply supported as shown.

Fendering, Lead-in Jetties and Dolphins—continued

stated, the greenheart is three times more efficient as a shock absorber.

A dolphin of the vertical dimensions shown on Fig. 7, if constructed of 20 14-in. x 14-in. greenheart piles would have a capacity of 1,950 inch-tons when stressed to 11,700 lbs. per sq. inch, and provided the piles did not extract, it would absorb 9,750 inch-tons before failure.

This gives some idea of the possibilities of greenheart dolphins for the entrances to docks, etc. No springs, etc., are required and the dolphin can absorb blows from any direction with equal ease.

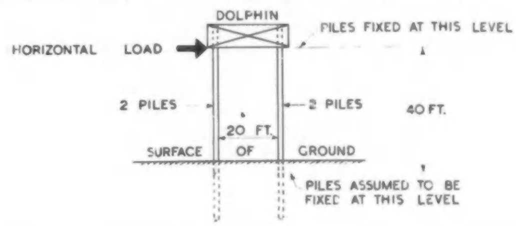
To construct dolphins of this high order it is only necessary to have long legs and a tension hold of the ground. It is not necessary to have fixidity at the ground as this has no bearing on the work absorbing capacity, only the static resistance and deflection.

Comparison of Jetty Bents.

Fig. 8 shows the work absorbed and forces resisted by bents of different materials and arrangements and is self-explanatory.

It will be seen that of the reinforced concrete designs the raker piled bent is superior, provided, and only provided the ground is such that a considerable tension hold can be obtained. Although this type of structure cannot absorb the amount of work the timber or steel bents can, it provides an excellent crane platform and gives passengers a sense of security due to the small deflection. They have usually a considerable static resistance and mass, and if rammed can, by virtue of the dispersal action of the deck fold up the bows of vessels. Raker piled bents have a considerable reserve capacity to absorb impacts if the piles are arranged in such a way as to lift the deck without setting up bending moments in this part of the structure. On the other hand, for lead-in jetties or dolphins where movement of the deck is not to be avoided, a greenheart structure has no equal. A great deal can be learned from a systematic study of old structures. Such an investigation shows that many timber and steel piers of over 70 years of age are in serviceable condition to-day, the latter only where 6-in. solid steel shafts or other sections with considerable thickness of metal have been used as piles and where all other members were constructed of metal having a minimum thickness of ¾-in. All steel deck beams and other members of the usual lighter rolled sections have not lasted as well as pitch pine deck beams.

except 12-in. x 6-in. rubbing pieces fixed direct to concrete members have proved a failure in all cases, except where the members have been massive. Fenders of larger scantlings supported close to concrete members have also resulted in trouble. The writer has on many occasions seen concrete members behind 12-in. x 12-in.



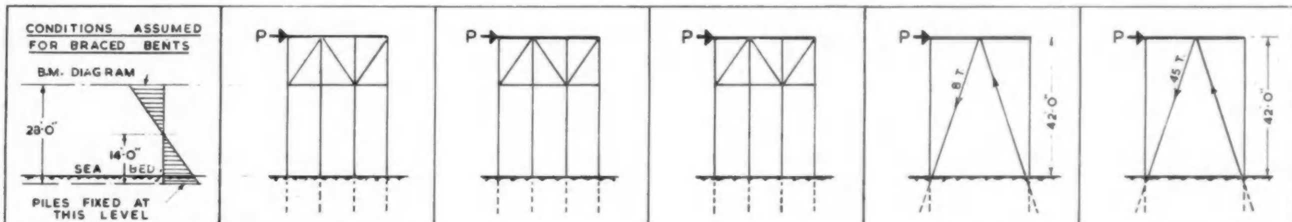
	B.S.P. BOX PILES No. 5	14" x 14" GREENHEART PILES
WORK ABSORBED	125 INCH TONS	390·0 INCH · TONS
HORIZONTAL LOAD RESISTED	45 TONS	39·8 TONS
DEFLECTION UNDER LOAD	5·54 INCHES	19·6 INCHES
RESISTANCE MOMENT OF PILE	2700·0 INCH · TONS	2390·0 INCH TONS
FORCE IN EACH PILE DUE TO OVERTURNING MOMENT	$= \frac{2700}{120}$ 22·5 TONS	$= \frac{2390}{120}$ 19·9 TONS
STRESS DUE TO BENDING	15 TONS/□"	11,700 LBS./□"

Fig. 7. Comparison of Dolphins, each with four piles.

timber and larger smashed to pieces while it was impossible to identify an impact mark on the timber that had transmitted the load to the concrete. On one occasion a corner of a jetty had been struck a violent blow by a 1,000 ton belted vessel when drifting at the mercy of a strong wind doing extensive damage to R.C. piles and braces, but the group of greenheart piles protecting the corner showed only a minor sign of the impact and one in particular must have deflected through more than 6-in. on a span of 16-ft. in order to transmit the load to the concrete.

It will be appreciated that these damages would not have taken place if the structures had been properly designed, but they are mentioned to give some idea of the resistance of timber and of greenheart in particular.

Steel fenders, on the other hand, are easily bent and if strong



TYPE OF PILING	GREENHEART	STEEL	CONCRETE	CONCRETE 8 TONS TENSION	CONCRETE 45 TONS TENSION
DETAILS OF PILES	14"x14"	12"x12"x82·55# B.F. BEAMS	15"x15" WITH 4No. 1⅜" ⌀	15"x15" WITH 4No. 1⅜" ⌀	15"x15" WITH 4No. 1⅜" ⌀
STRESSES	11,700· LBS/□"	15·0 TON/□"	14·0 TONS FOR STEEL		
RESISTANCE MOMENT OF PILE	2385· INCH-TONS	1630· INCH-TONS	400· INCH-TONS	400· INCH-TONS	400· INCH-TONS
LOAD 'P'	56·8 TONS	38·8 TONS	9·52 TONS	10·0 TONS	34·0 TONS
DEFLECTION OF 'P'	9·62 INCHES	3·49 INCHES	1·37 INCHES	0·132 INCHES	0·439 INCHES
WORK ABSORBED	272·8 INCH-TONS	67·6 INCH-TONS	6·52 INCH-TONS	0·66 INCH-TONS	7·45 INCH-TONS
RELATIVE EFFICIENCY	100%	24·8%	2·39%	0·24%	2·74%

Fig 8. Comparison of Jetty Bents.

Many of the braced R.C. piled piers of 40 years of age have suffered badly due to the low work absorbing capacity of the bents, the poor durability of the concrete and small deck beams, and insufficient cover to the reinforcement. Some of these are now beyond repair. The use of flat slab decks and circular raker piles, together with good fendering give every indication of giving good and lasting service where such structures have a high static resistance and mass. R.C. designs which were stripped of all timber

and stiff damage the vessels. Even very strong steel fenders and face piles develop a permanent set after a time.

Fendering.

Fig. 9 shows two type of resilient fendering both capable of absorbing impacts from general traffic in the order of 400 inch-tons and over.

It is only necessary for the lower waling of Type A. to spread

Fendering, Lead-in Jetties and Dolphins—continued

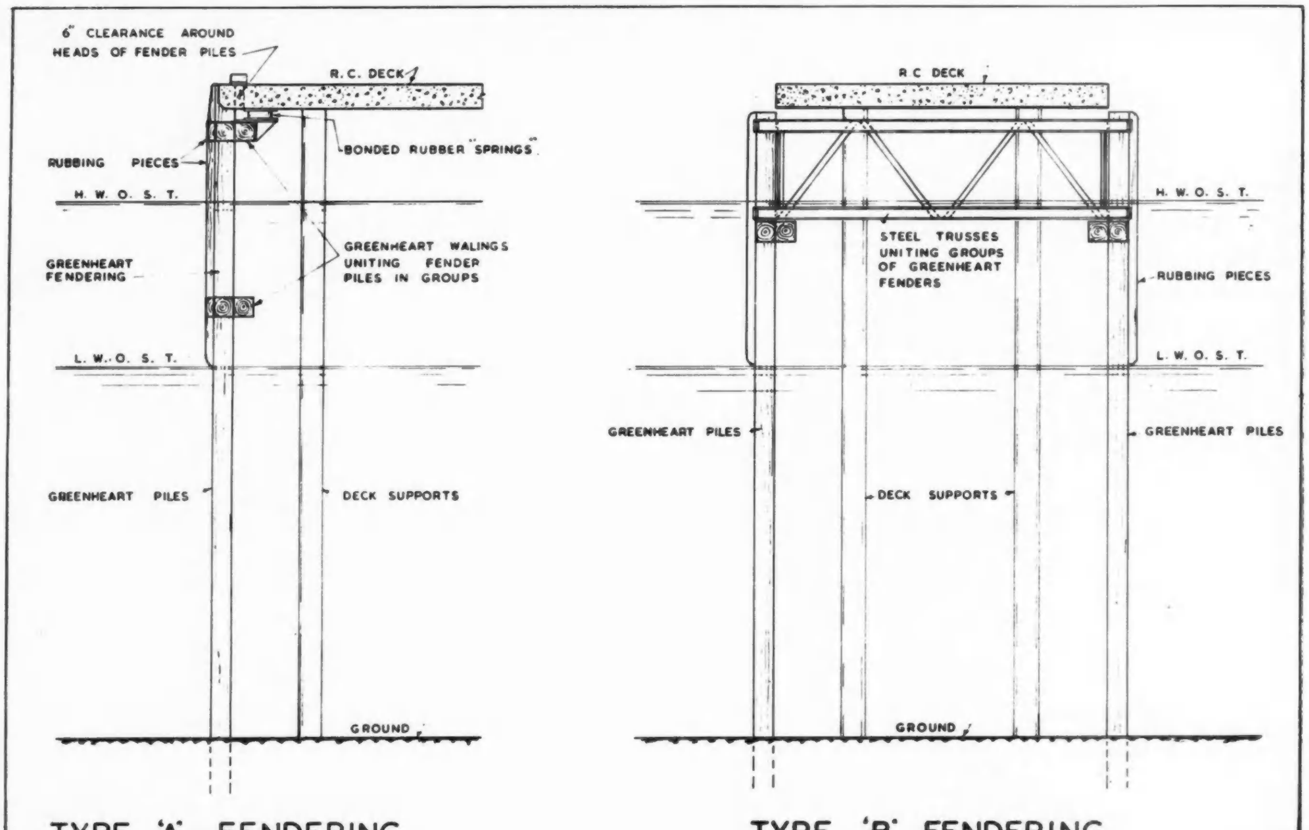


Fig. 9.

an impact into three 14-in. x 14-in. greenheart fender piles of 40-ft. span for the arrangement to have a capacity of 400 inch-tons when the timber is stressed to 11,700 lbs. per sq. inch. A 14-ft. x 14-ft. greenheart waling is capable of this dispersal of a point impact when the piles are spaced at about 10-ft. centres or thereby. Further it is capable of resisting low level impacts of 400 inch-tons without the assistance of springs. These springs shown under the deck in Fig. 9 are rubber bonded units, originated by the Admiralty and developed by their Civil Engineer-in- Chief in collaboration with the Andre Rubber Company. They are manufactured in a variety of sizes but the ones shown are 21-in. diameter by 6-in. thickness, capable of moving through 6-in. under a load of 25 tons and absorbing 75-in. tons of work and are of course equally effective in resisting longitudinal impacts

Fendering very similar to Type A, but with independent rubber of a compression type, consisting of 14-in. x 14-in. greenheart piles at 10-ft. centres independently sprung at their heads and having a free span of a little over 40-ft. has been in use for some years and is a great success.

Fendering of Type B (Fig. 9) is for use with narrow jetties. This type can have a very high work absorbing capacity and unlike the usual gravity fenders is capable of absorbing impacts acting in any direction. An eight pile portal fender unit of Type B with piles fixed in the ground and having an effective length of 40-ft. can absorb 780 inch-tons with a movement of 19.6-in. when stressed to 11,700 lbs. per sq. inch, and 3,900 inch-tons at failure of the greenheart. This type of fender is such that the fender piles can be driven first and the connecting trusses fixed to act as a staging for the heavy piling plant and deck shuttering.

Most systems of fendering which have proved successful have flush faces, and this is an important consideration.

The fixing of rubber pieces in such a way that they can be knocked off by drag forces without damaging the fender piles, the fixings of the gland type, not requiring the drilling of the logs, and the jointing of walings are some of the points requiring care and attention if the best is to be obtained from greenheart.

Greenheart forms excellent rubbing pieces when fixed on spring fenders, but they should be provided with anti-splitting bolts at their ends to get the best out of this timber. Greenheart can take over three times the bearing pressure resisted by softwood, namely 1,980 lbs. per sq. inch, and in consequence it is superior for resisting belted vessels.

Greenheart.

Greenheart is an Empire and Sterling area timber and as it is now the same cost as properly creosoted softwood and vastly superior, there is now no need to consider softwood when dealing with marine structures.

Before the war, greenheart was twice the cost of pitch pine, but even then it was extensively used for fendering and from a recent inspection of " spring " greenheart fendering that saw heavy war use there is no doubt that the extra cost was well worth while.

Greenheart holds second place of the eight woods rated as A.1. at Lloyds, the first place being given to teak.

It weighs half the weight of concrete and requires lighter and usually more easily obtainable plant. It is one of the most durable timbers in salt water and far superior to creosoted Douglas fir in this respect.

Greenheart is not weakened by knots and faults as many other timbers, and from observations carried out over the last 22 years on both new and old greenheart, the latter obtained from structures of over 80 years old, the writer is of the opinion that it is more consistent and fault free than many R.C. members.

The ultimate tension of greenheart at fracture is over twice the crushing resistance of the best factory made concrete at failure and this gives some idea of how poorly a prestressed concrete fender pile compares with one of greenheart, bearing in mind that work absorbed is proportional to the stress squared.

Greenheart is very easily worked by modern tools and is now available in sawn logs.

(concluded on page 25)

Large Dry Docks

The Trend in Vessel Sizes and Future Docking Requirements*

By E. LESLIE CHAMPNESS, M.B.E., M.Sc.
(Managing Director, Palmers Hebburn Co. Ltd.)

Introduction

THE two large dry docks at Sydney and Capetown were discussed in papers read before the Institution of Civil Engineers early in 1948, following which a special Dry Docks Committee under the chairmanship of Mr. M. G. J. McHaffie was initiated by that Institution, charged with reviewing the design and equipment of dry docks.

At their request the Institution of Naval Architects appointed two representatives—Mr. G. McL. Paterson and myself—to this committee to represent the naval architectural point of view, and to give such assistance as we could on the main committee and on various panels, together with many experts experienced in civil engineering and mechanical equipment connected with dry docks, cranes, pumps, etc. The results of their deliberations were published by the Institution of Civil Engineers in 1952 as " Dry Docks —Memorandum on Construction and Equipment."

The Admiralty point of view was of course well taken care of by separate and direct representation on this committee both of the Director of Naval Construction and Dockyard and Civil Engineering Departments; their requirements and resources differ to some extent from those of private docks, though inevitably in times of emergency the Admiralty becomes a major user of private facilities.

No doubt this brief Memorandum will be studied in some detail both by those contemplating building new dry docks and by the various experts who carry out such projects. At any rate the numerous headings of almost everything concerned were raised therein and the merits or demerits of alternative equipment were very fully discussed in committee, though little of this appears in the Memorandum itself which, under the terms of reference, restricts itself to summarising the conclusions reached.

Not all of this is much more than of general interest to those who are the users of dry docks, who are chiefly concerned in getting the most efficient service they can, nor to all dry dock owners, though much of it will amply repay study by them; and if they are private dry dock owners they will doubtless weigh up the commercial return or necessity for all the items dealt with in this comprehensive survey. Much depends on the demand and type of work undertaken by particular private establishments, and the diversity and incidence of this colours the individual requirements and necessities of private firms.

Opinions and experience naturally vary but almost all aspects are covered by this Memorandum and much valuable information is at the disposal of the private dry dock owner contemplating expansion.

The notes initially given to this Committee in April, 1948, as representing the naval architecture point of view on the particular questions of proportions of length to beam, naval requirements of the future and dock proportions and facilities, are given below. No events have occurred since then, within my knowledge, to change these opinions.

Trend of Proportions of Length to Beam

In an examination of a number of large merchants and passenger liners for proportion of length to beam, it will be found that—irrespective of their particular service (i.e. Atlantic, Pacific or Europe—Far East, via Suez or Panama), they range from Beam = (L over 10) + 5-ft. to (L over 10) + 21-ft. where L = length overall in feet. The beam of present-day vessels tends towards the upper limit.

Certain special classes of large merchant vessels, 500-ft. to 700-ft. in length, such as whale factories, oil tankers, and ore vessels are generally of the (L over 10) + 20-ft. type and some with slightly greater beam. Some types of naval auxiliary vessels such as depot ships, fleet repair ships and the like also rise to similar proportions.

From the purely naval architecture design point of view, the natural expansion over the years of passenger and cargo vessels for minimum transportation costs would be increase of draught (see Sir John Biles, " The Draught and Dimensions of the Most Economical Ship," TRANS. I.N.A., 1931).

In actual fact, the draught of the largest ships is still limited not so much due to dry dock availability as to the depth of major canals, dredged channels or other terminal facilities, so that the normal developments in the period 1910-1948 have increased liner dimensions from 700-ft. to over 1,000-ft. in length; but corresponding increase in load draught has only risen from 35-ft. to about 40-ft.

Designers are thus still driven to length and beam as the only possible expansion directions, owing to these world limits of depth of water.

This tendency to increased beam proportions in passenger liners over the past 40 years is chiefly due to the increased top hamper from the original modest type to present luxury types, and since this has now reached a probable maximum it is unlikely that corresponding increase will take place in the future. Light alloy material is also now available and likely to be used increasingly for superstructures and boats, etc., which will not necessitate increase of beam stability purposes.

The proportions of docks proposed in Fig. 1 should not, therefore, be overtaken in the future by developments in ship proportions such as has occurred over the past 40 years which has already caused many dry docks to be relatively too narrow to-day.

Naval Requirements of the Future

As the age of assured world peace and abolition of armaments still seems to be an ideal a long way off, requirements for all dry docks must still take cognisance of naval requirements since, as always, civil docks must be used in assisting state dockyards in national emergencies.

The past tendencies in naval design in the pre-atomic period up to 1944 show the same trend as for all other vessels, namely steady and progressive increase in size, though generally with extreme beam characteristics.

The largest key vessels setting the pace for dry docks (or perhaps more correctly whose dimensions have been limited by existing or projected dry docks) were battleships and aircraft carriers.

The latest published information as to the tendency and size of battleships in the pre-atomic era is probably that given by Commodore Schade, U.S.N. (Trans. Society of Marine Engineers and Naval Architects, New York, 1946) on " German Wartime Technical Developments." This quotes the developments of the German "H" type of battleship, one of which was laid down by Blohm and Voss at Hamburg in 1939 and never completed. The design was under continuous review on paper by the German naval authorities and increase in size and proportions was made from 910-ft. length, 122-ft. beam and 33-ft. draught, to 1,132-ft. length, 169-ft. beam and 44-ft. 3-in. draught.

For these vessels Germany constructed three dry docks at Hamburg, Bremen and Wilhelmshaven—now all destroyed—(1,020-ft. to 1,140-ft. × 197-ft.).

As far as very large capital ships with normal pre-atom armament are concerned, the tendency appears to be for beam proportions to extend very rapidly, requiring dry docks of extreme breadth which would be uneconomical for ordinary normal requirements.

These vessels and the large capital ships (see Dr. Oscar Parkes, TRANS I.N.A., 1949) and the present United States aircraft carrier policy represent so far the upper limits.

There is as yet no information nor actual building of new vessels,

*A Paper (slightly abridged) read before the Institution of Naval Architects, March, 1953. Reproduced by permission.

Large Dry Docks—continued

which indicate the probable tendencies of naval construction embodying the results of the observations of the 1946 Bikini and later atomic bomb experiments or radar developments, except in smaller craft for submarine detection and offence. General naval and technical opinion indicates that the existence of such weapons, though they may change the character of naval fighting units, will not see the end of seaborne navies, either for offence or commerce protection. It may well be, however, that the fleet of the future may consist of smaller units, more readily dispersable.

Since this matter of naval tendencies concerns only the docking facilities for very large types of capital ships, and such large projects as super-dry docks will not be lightly entered upon in present days of high cost levels, it is probable that the trend will be clearer before any such enterprise is begun.

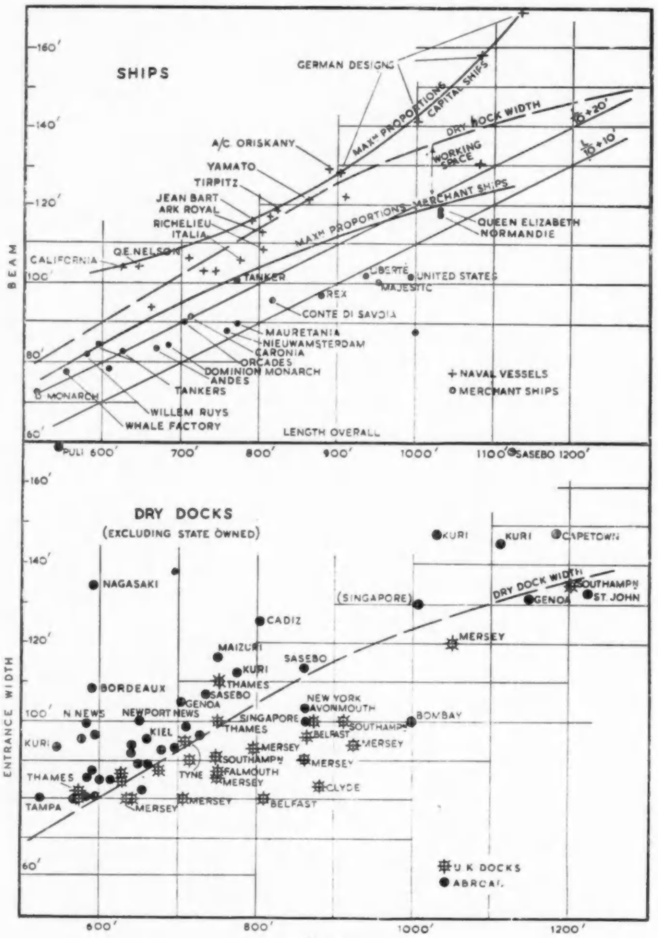


Fig 1.

Note: the curve of dry dock width in the upper part of the figure is the curve of ideal width suggested; the curve of dry dock width in the lower part of the figure is 10-ft. less width than the upper.

Suggested Dock Proportions

The upper part of Fig. 1 indicates the proportion of a number of past and present large merchant and war vessels with enveloping curves of maximum proportion of length to beam. From the merchant ship point of view this gives rise to a curve of dry dock width on a basis of length overall allowing suitable clearance for repairs.

Smaller length vessels with out-of-proportion beam can generally be accommodated in dry docks (of which there are probably a large number) up to 100-ft. longer than the vessel itself, and this applies to vessels such as naval monitors and Maracaibo types of oil tankers.

The lower part of Fig. 1, on the same basis, indicates the overall length and average entrance width of large docks in this country and abroad.

The fact that all but about six of the existing United Kingdom mercantile dry docks lie below the line of ideal entrance width for present-day lengths, whereas over 50 dry docks abroad, apart from floating docks, lie above this curve indicates the extent to which many United Kingdom docks are now out-of-proportion with modern trends.

General Position

Apart from the deliberations of the Dry Docks Committee referred to, it has been apparent for some time that there is an increasing pressure on large docks to-day, particularly in United Kingdom, and it is a matter of some concern to those interested. Mr. Basil Sanderson (TRANS. I.N.A., 1952, page 186) refers to this and quotes the corresponding increased fuel costs to owners.

Commercially the dominating and governing factor to-day is the constant development of the oil tanker which, as she ages, necessarily involves rather more extensive upkeep repairs and steel working facilities than those required for large ocean liners at fixed terminal ports, and by their numbers these tankers form the major user of large facilities. It is therefore not inopportune to examine the position as to the trend of events in some detail.

Fig. 2 indicates the approximate proportions of modern tankers over 20,000 tons deadweight and the number of British United Kingdom dry docks capable of accommodating the various sizes

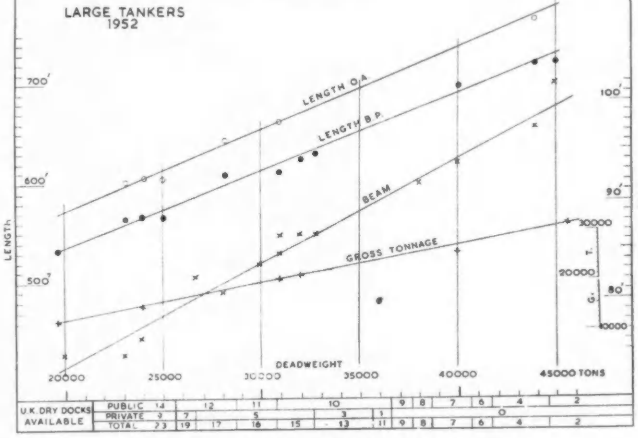


Fig. 2. Large Tankers, 1952.

which rapidly decreases with size; indeed the largest tankers now building and projected, exceed the limits of British private docks available with repairing services.

In the following rough analysis from published information Appendix III of Lloyd's Register of Shipping (1952) relating to existing effective dry docks, etc., dry docks 540-ft. in length and marine railways, slipways and floating docks under 8,000 tons lifting power have been ignored.

The lower limit of 80-ft. beam in the table below represents oil tankers of approximately 26,000 tons deadweight, and passenger ships of about 22,000 G.R.T.

State-owned docks are not available to merchant ships generally except in emergencies, and many public docks, particularly those in terminal ports with liner traffic traffic and commitments, are not generally available for long term repairs.

This position as to private dry docks has remained practically stagnant for many years in spite of the increasing size of merchant ships, and the long memories of the years of depression still seem to colour the situation.

The growth of demand for larger sizes has not remained constant, however, and is indicated roughly by Table II.

In considering Table II which has been taken down to 70-ft. beam, allowance should be made for working space necessary round ships under repair, when comparing the numbers of docks available as per Table I. The growth of numbers in the 80-90-ft. beam class is notable.

Large Dry Docks—continued

These vessels, being total world tonnage, do not all trade to Britain but reflect the general increase in beam; but the figures for British owned tonnage show equivalent increases.

In relation to its mercantile shipowning interests the declining position of the United Kingdom in failing to keep pace with increasing size in private and public docks is significant. There is a probable deficiency in the number of dry docks for merchant ships in this country, not only in the larger ranges but certainly for all sizes of ships over 65-ft. beam, which need a working width of about 75-ft. or more for repairs, and the growth in numbers of these vessels in the last 30 years with an almost unchanged United Kingdom dry dock position is very considerable, i.e. probably about ten times.

TABLE I—Number of Docks available.

Entrance width	Dry docks			Floating docks			Total		
	80-ft and over	90-ft. and over	100-ft. and over	80-ft and over	90-ft and over	100-ft and over	80-ft and over	90-ft and over	100-ft and over
Mercantile dry docks									
Public and private									
U.S.A.									
Atlantic	8	4	1	38	18	4	46	22	5
Pacific	7	1	1	18	13	1	25	14	2
Total	15	5	2	56	31	5	71	36	7
Gt. Britain									
Public	15	10	6	—	—	—	—	—	—
Private	10	3	—	—	—	—	25	13	6
Total	25	13	6	—	—	—	25	13	6
S. Africa ..	3	2	2	—	—	—	3	2	2
Canada									
Atlantic	1	1	1	2	2	2	3	3	3
Pacific	—	—	—	3	3	1	3	3	1
Australia and N.Z. ..	2	—	—	1	—	—	3	—	—
Other Commonwealth ..	3	2	1	—	—	—	3	2	1
Japan	20	17	9	1	—	—	21	17	9
Italy	5	5	3	—	—	—	5	5	3
Holland	1	—	—	8	6	4	9	6	4
Germany	5	2	—	4	3	2	9	5	2
France	5	4	3	4	—	—	9	4	3
Sweden	3	—	—	5	1	—	8	1	—
Belgium	3	1	—	—	—	—	3	1	—
Spain	3	2	1	—	—	—	3	2	1
Other countries ..	8	1	1	3	3	3	11	4	4
Total	102	55	29	87	49	17	189	104	46
State owned dry docks									
U.S.A.									
Atlantic	19	16	10	—	—	—	19	16	10
Pacific	20	17	12	1	—	—	21	17	12
Total	39	33	22	1	—	—	40	33	22
Gt. Britain									
Home dockyards ..	14	12	8	1	1	1	15	13	9
Foreign and Commonwealth ..	13	11	5	3	2	2	16	13	7
Total	27	23	13	4	3	3	31	26	16
France and Colonies ..	18	16	11	—	—	—	18	16	11
Italy	6	6	5	2	2	1	8	8	6
U.S.S.R.	4	3	1	1	1	1	5	4	2
Other countries ..	5	4	3	1	1	1	6	5	4
Total State	99	85	55	9	7	6	108	92	61
Total public and private	102	55	29	87	49	17	189	104	46
World total all docks ..	201	140	84	96	56	23	297	196	107

Two or three years at least are required for the construction of a large dock at present, so that this is a matter that cannot be suddenly righted.

This country is not a large user of floating docks, and one of the chief reasons is that apart from life and maintenance and vulnerability, the depth of water available is not generally sufficient on the rivers and estuaries where our major repairing facilities and manpower are available.

Vulnerability is in fact a relatively small detail matter in mercantile dry docks and concerns chiefly armouring of gates and dispersal of pumping facilities.

As obsolescence, all over the world, overtakes the older dry docks, outmoding them particularly in beam, then replacement costs must force dock dues into line with this world of changed values. The large number of medium size docks available may delay this in their case—but it is on the large size dock that the greatest pressure and demand will come. In all extensions to and construction of large size docks, i.e. the expansion of the industry to meet modern trends, the problem is urgent and is with us to-day.

These uncertainties are aggravated by the withdrawal in the 1951 Budget of the initial allowances for depreciation, and there is naturally a strong feeling that enterprise, embarked upon under given and stated conditions of relief, should be at the mercy of sudden changes in financial policy which completely undermine the stability of projects of this character. These are in the national interests and have previously required courageous decision in the light of present-day conditions.

The need for reduced State expenditure and consequent reduced taxation are with us in all walks of life, but until and unless this can be achieved some other relief is necessary.

It is also vitally necessary to the industry that more adequate depreciation allowances within shorter periods should be granted if any future expansion is to take place.

Unlike a ship or plant, an obsolete dry dock generally is a liability and has no residual value. The position of the dock owner is therefore worse in this respect than many other forms of business.

TABLE II

World Tonnage—30 Years' Increase in Beam

Mercantile Passenger or Cargo Vessels and Tankers

	Gross tonnage over 70 ft. beam	No. of vessels 70 ft. beam and over	Number of vessels with beam: Over 70 ft. and under 80 ft.	Over 80 ft. and under 90 ft.	Over 90 ft. and under 100 ft.	100 ft. and over
*1924	1,579,502	80	70	5	3	2
*1952 (October)	7,973,739	510	376	123	7	4
1954 (estimated)	9,750,000	663	500	150	9	4

*By courtesy of Lloyd's Register of Shipping

This position reflects the discouragement of necessary enterprise and the urgent necessity for a system of non-penal taxation which ceases to bleed industry of its powers of replacement and expansion but spreads obsolescence. This is a political matter of first-class importance to this country, particularly at the present time.

Discrimination in taxation between industry and industry is not a popular thought, but in this wider issue and background of security in which shipping and those interests which serve it are bound up, we may have to revise our thoughts if we are to avoid stagnation and if there be no other means of relief.

Those who have been through two World Wars need no warning of the serious effects of unpreparedness in emergency.

Economic Considerations of Present-Day Expansion

Even with an existing organisation, land and ancillary shops and services, the cost of a dock of 700-ft. to 900-ft. at to-day's level will vary from one million to two million pounds, depending on dimensions and local circumstances, and the extent of ancillary shops and services provided.

Where a major project has to be laid down on virgin ground with reclamation work and completely new facilities such as the Garden Island project and the Captain Cook Dock at Sydney—(1,133-ft. × 140-ft.) (1941-1945), the cost was approximately £8 million, and in the Sturrock Dock installation at Capetown—(1,181-ft. × 148-ft.) (1943-1945) the dry dock itself cost £3½ million, excluding the prior reclamation work.

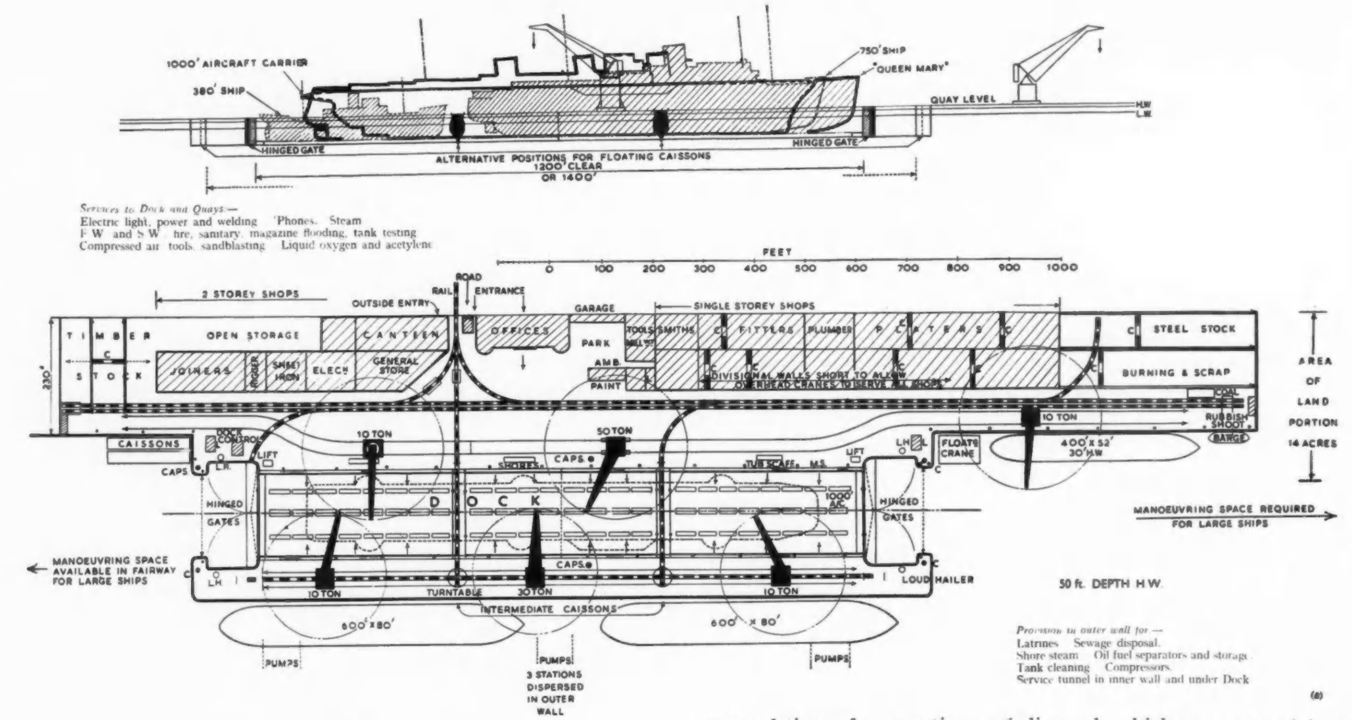
This expenditure, necessary as it was for strategic reasons, is beyond the commercial sphere where in private enterprise there is a necessity for adequate return for capital expenditure.

A dry dock continuously full with large tankers of 37,000 tons deadweight with an approximate gross tonnage of 25,000, for every working day of the year allowing a 6-day week (instead of five and holidays), would earn a total return in dry dock dues at existing rates of £90,000 per annum gross against which the upkeep and working costs must be charged to arrive at a net return.

The premises of full and capacity occupation and full use of time are (of course, impossible to achieve in practice and the probable return even in to-day's busy time would be more likely to be about £35,000 per annum net.

This return even upon capital expenditure as low as £1 million apart from the depreciation factor, would scarcely justify the enter-

Large Dry Docks—continued



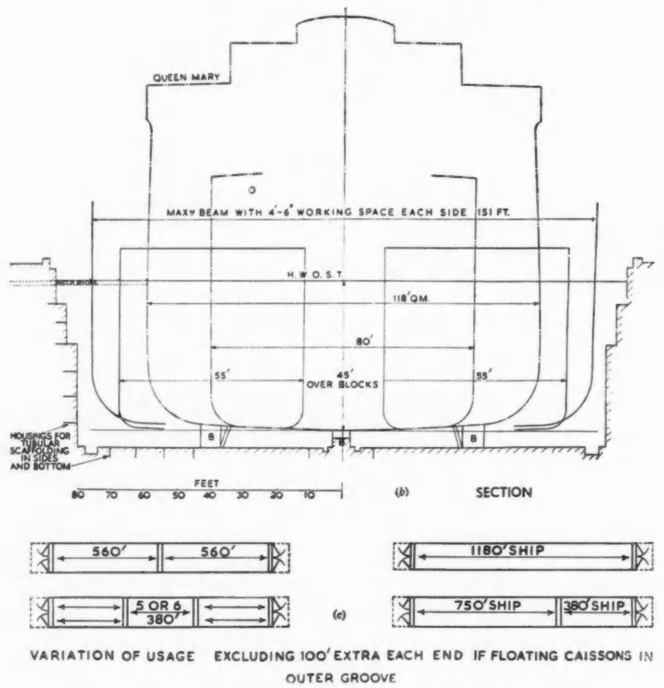


Fig. 3. Ship Repairing Yard for a Deep Water Port.

prise by itself, and one would have to rely on attracting additional repair contracts which one would not otherwise get but for the possession of such a dock, from which an adequate return was obtainable. If this is not possible the only alternative is the raising of existing dock dues (which were based upon construction costs of most existing dry docks at about one-fifth of the present level) to rates bearing a more realistic relation to expenditure.

One would like to look to our civil engineering friends for a technique and plant, by drag-line or otherwise, which would reduce the present heavy costs of construction.

There seems to be some scope for this, particularly in the high cost and time of excavation and disposal, which can amount to 15 per cent. of the total cost.

On such conditions and considerations the necessary modernisation and up-to-date expansions of British facilities for the handling of large ship repairs depend to-day.

This point of impossibility of full capacity occupation—the need to have these large dry docks when called upon—but the inability to fill them with ships of that size means that these large dry docks of 1,000-ft. length and over spend the most of their time uneconomically used for one ship of a little over half the length of the dock, or sometimes two small ships docked simultaneously. That is not surprising when there are at the present time only some 40 merchant vessels afloat—world tonnage not all British—over 80-ft. beam and over 650-ft. overall length. The largest dry docks therefore serve a limited class but this number will be augmented shortly by about two hundred large tankers.

The provision of an intermediate gate with the idea that by so doing a long term job can be taken on in the inner portion whilst using the outer part for routine short term jobs, does not seem to work out in practical reality; and these intermediate gates seem rarely to be used in practice or justify the extra expense of their provision.

This economic question of maximum possible usage leads to an excursion into the design of ship-repairing premises from the users' point of view alone, not as a civil engineer, and gives rise to Fig. 3.

It involves a reorientation of the normal layout square or obliquely off the fairway into one with the dock parallel to it. Those who have experienced beam winds and gusts, heavy stream water on the beam in tidal rivers—particularly after the turn of the tide due to late arrival of ship (or pilots and tugs), will agree that it is somewhat easier to handle ships into such a dry dock than the normal type.

The real point, however, of the double-ended large dry dock design with variable position of one or more intermediate gates, is the large variations in occupancy and flexibility which is possible, and serves to overcome the full-employment-white-elephant problem previously referred to.

These alternative uses are shown on Fig. 3.

It is a possible arrangement with the outer wall constructed on reclaimed land as shown or with certain site shapes, or indeed when the inner end is adjacent and can be connected up with a wet basin, assuming, of course, the nature of the ground and water level, are suitable.

Large Dry Docks—continued

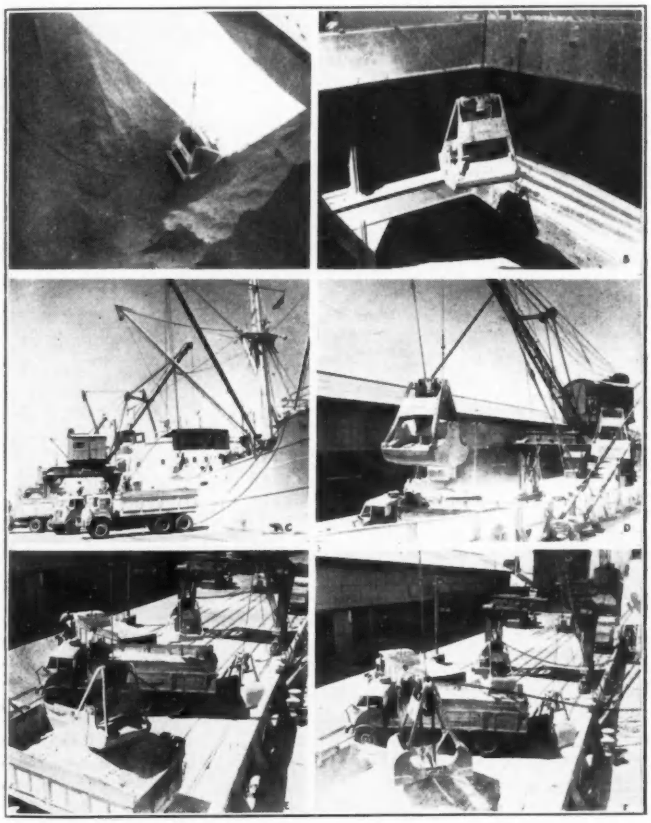
Not the least important matter bearing on the pressure of dry dock capacity to-day and the future of the ship-repairing industry in this country competing with Germany, Italy, the near Continental ports and Japan, is the time factor.

Like port delays, time for repairs is increasingly important with larger and costlier units off earning time. There is a vital necessity for both sides of the British industry to realise that with competition even initial cost of repairs can be to some extent secondary in busy times to speed of turn-round, such as is accomplished by our foreign competitors working a 3-shift system and every day of the week. Opposition to overtime and demarcation difficulties in this country are long overdue for consideration and amendment if the industry is to maintain its position in more difficult days.

Grabs Working from Ship's Derricks

The composite photograph below shows the cycle of operation of a 21 cu. ft. heaped and 17 cu. ft. flush dumping single chain operated grab, handling phosphates and working from ships' winches by the "Union Rig." The jaws are of special construction to eliminate leakage and are effectively sealed by a rubber strip along the edges of the jaws.

Numbers of these grabs are operating satisfactorily for the British Phosphate Commissioners in Western Australia.



[Photograph by courtesy of Priestman Brothers

The sequence of operating is as follows:—

A. View taken from deck level above No. 1 hatch showing the grab ready for digging the phosphate rock. Note the deep angle at which phosphate rock reposes and the ability of the grab to obtain a full load on this slope.

B. The grab has now obtained its load and is being hoisted to the top of No. 1 hatch on the inboard winch attached to the main grab closing chain. The second line attached to the outboard winch is commencing to take a portion of the load.

C. The grab is now being swung to the discharge position with the majority of the load taken on the second outboard winch.

D. Close-up of grab swinging to discharge its contents in the lorry, the main lift now being taken by the outboard winch, whilst the inboard winch commences to pay out slack in the main grab closing chain.

E. The grab is now suspended entirely by the outboard winch preparatory to being dumped on the lorry. Note the slack in the main grab closing chain.

F. View showing two grabs with the material fully discharged after being automatically dumped by the outboard winch driver without any manual assistance.

With these grabs an average output throughout the whole of the cargo of 25 tons per hour per grab is obtained.

Fendering, Lead-in Jetties and Dolphins

(concluded from page 20)

Research and Development.

The foregoing facts clearly indicate that greenheart in bending is superior to any other material of comparative cost but as most young engineers look upon timber as a very variable poor structural material the development and improvement of general purpose fendering will to a great extent depend upon a systematic programme of research, development and education being undertaken on the following lines:—

(1) The first step in any development of this nature would be the marketing of tested and guaranteed greenheart logs.

(2) A survey of all existing greenheart spring fenders and the avoidance of weak arrangements.

(3) Tests to determine the maximum repeated stresses greenheart can withstand without any permanent deformation or weakening, based on the rate and duration of loading associated with fenders in practice.

(4) The development of joints not dependent on through bolts by testing and the publicity of such test results.

(5) The determinaiton of the failure stresses for dolphin legs and the like, subject to combined bending and compression.

Conclusion.

It will be seen that there is every reason to believe that greenheart has no equal for (a) Fendering for general purpose berths; (b) Dolphins; (c) Lead-in jetties. Damage to lead-in jetties and the like is usually of a local nature when timber is used, but if a rigid structure is used for this purpose there is always a chance that the damage to ships will be extensive and will give the dock a bad name and may even involve the owners in litigation.

Some of the recent fendering devices used and proposed, makes one wonder how vessels were berthed at all before the war when such devices were few and far between. Berthing tankers at exposed sites is a very special problem not to be confused with a general purpose wharf or pier where the more normal spring fendering is satisfactory.

There has been a notable reluctance in some quarters to make use of long fenders and apply the principle that the work absorbed is proportional to the length.

The perfect fendering capable of resisting the drag forces set up by projecting anchors, etc., without damage is not likely to become readily available but very serviceable fendering can be constructed and maintained at relatively small cost by using greenheart as indicated in this article.

During the last war all sorts of fenders had to be used with a view to saving timber and rubber. Most of the steel systems of fendering devised were easily damaged and on the whole they showed just how good was a really good system of greenheart fendering for general purpose berths.

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The Properties of Aluminium and its Alloys

By J. LOMAS.

Aluminium is a metal of white or silvery hue, possessing only moderate tensile strength, but excellent malleability combined with thermal and electrical conductivity. It has an atomic weight of 26.97, an atomic number of 13, and a melting point of 658.7 deg. C. Its specific gravity is 2.58, but if the metal is hammered or rolled, this may be increased to about 2.69. From the point of view of the dock and harbour engineer, its primary qualities when in the form of extruded or rolled sections employed in structural work are its lightness and resistance to atmospheric corrosion. In the following table are given the specific gravities of some of the commoner industrial metals and alloys, showing the position of aluminium in comparison with these.

TABLE I

Material.	Specific Gravity (approx).
Aluminium	2.70
Brass	8.4
Bronze	8.6
Copper	8.8
Lead	11.3
Magnesium	1.75
Nickel	8.9
Tin	7.3
Zinc	7.2

From the engineering aspect, as stated, the primary property of aluminium is its low density. It has, however, the disadvantage that it is mechanically weak, having in the cast condition a tensile strength of only 6 to 7 tons per sq. in. and an elongation of about 3 per cent. This makes it unsatisfactory for castings called upon to exhibit high strength. Against this, however, it is malleable and therefore suitable for hot or cold working, which latter operation has the effect of increasing the tensile strength to about 12 tons per sq. in. Even this is hardly adequate for many vital purposes, and for this reason alloying elements are, as we shall see, frequently introduced into it to give it superior mechanical properties.

The commercially satisfactory aluminium sheet is actually an alloy containing small proportions of iron and silicon, some qualities containing even as much as 1.25 per cent. of manganese. The metal and its alloys may all be manipulated and built up by the ordinary working processes, e.g. rolling, stamping, forging, spinning, drawing, extruding, casting and die casting. Commercial aluminium is a good conductor of electricity, having a specific electrical conductivity of about 61 per cent. that of copper, but pound for pound, it is, in fact, better than copper as a conductor, and for this reason is much used for making electric cables, though because of its weakness, it is strengthened by a steel wire reinforcement.

By reason of its high conductivity, it is widely used in making domestic hardware, and its alloys for such parts of internal combustion engines as cylinder heads and pistons. Moreover, aluminium constitutes an excellent reflector for radiant energy, and this makes it highly suitable for the most up-to-date telescope reflectors, light reflectors, etc. In the form of crumpled aluminium foil wrapped about the part to be insulated, it is also greatly used for the thermal insulation of pipes or flat surfaces because of its high reflecting power for thermal radiation. The crumpled sheets of foil are separated by air spaces, thus providing most effective insulation. The structure comprising the layers of foil is maintained in place by spacing wedges, and a thin sheet steel covering spot-welded on to it. Another use is the manufacture of aluminium paints, for which purpose it is made into either a powder or a paste. It is also employed as a deoxidizer for molten steel, and for corrosion resisting plant in various industries.

Like all other metals, aluminium has a crystalline structure, and is obtainable in a very nearly pure form (99.8 per cent.). Its density, which varies with temperature, is 2.6989 g. per c.c. at 20 deg. C. in the cold-rolled state, and 2.6996 g. per c.c. in the annealed condition. The density may be slightly reduced by cold working, and increased by a later annealing. Thermal expansivity is, according to the Aluminium Research Association, given by the equation:

$$L_t = L_o\,(1+23.22t-0.00467t^2-0.0000078t^3)\ 10^{-6},$$

where t is the temperature, L_t the length at this temperature, and L_o the length at 0 deg. C.

Aluminium has a thermal conductivity of about 0.55 c.g.s. units at normal temperatures, as against values of 0.92 and 0.17 for copper and iron respectively. It may be fully softened after cold-working by an annealing or recrystallization treatment, which reduces the mechanical strength of the metal to about its original amount before cold working, but at the same time greatly increases its ductility, the elongation being raised to about 40 per cent. in 2-in.

The reader must not suppose that aluminium is completely corrosion-resistant. It can be severely corroded by certain acids, alkalis, and salt solutions, particularly if it happens to contain an unduly large percentage of impurities. Nevertheless, it is virtually immune from normal atmospheric corrosion. This is because when it is brought into contact with air containing a small percentage of moisture, an oxide film forms on the surface, and this, though of no great thickness, is impenetrable by further oxygen, so enabling the metal to resist further attack. Still greater film hardness and corrosion resistance can be obtained if the oxidized film is formed and reinforced by electrolytic means (anodized), and it is noteworthy that the surfaces so oxidized can be made to take on different tints, either by means of dyes or by impregnation with special pigments.

The normal ability of aluminium and its alloys to withstand corrosion is, as stated, the result of a protective oxide film. The natural film is, however, extremely thin, so that processes to reinforce this by a thicker and more firmly adherent film have been developed. This improves corrosion resistance. The parts to be treated constitute the anode when immersed in a suitable electrolyte solution. The well-known Bengough-Stuart process employs a 3 per cent. solution of chromic acid (H_2CrO_4) in water at a temperature of 40 deg. C.

The film thickness produced is about forty times that of the natural coating. The film is sub-microscopically porous, but the pores can be sealed by greases and waxes, e.g. lanoline or beeswax, still further increasing the resistance to corrosion. As an alternative, the pores may be sealed and the film coloured by immersion, immediately after rinsing, in inorganic or organic dyestuffs.

Most of the light aluminium alloys can be successfully oxidized by anodic processes, but alloys with more than 5 per cent. of copper and those rich in silicon present some difficulty. In every instance the parts must be thoroughly cleaned before oxidation. Degreasing, followed by alkali cleaning, may be necessary in some instances, but the use of caustic soda for cleaning aluminium parts is inadvisable. After anodizing, even better results are obtained by plating and/or enamelling.

Another drawback to the widespread use of " pure " aluminium in engineering is its unsatisfactory machining properties. When subjected to the action of cutting tools in lathes, planers or shapers, it is liable to tear badly, while it is impossible to form fine screw threads on it. To render it machinable, it must be given small percentages of toughening elements, as we shall see. These elements sometimes make the metal a little heavier, but never so much so as to destroy the advantage of lightness the metal possesses. Moreover, by making the resultant aluminium alloys stronger as well as more machinable, they increase their range of applicability, while in some instances their superior thermal conductivities at high temperatures make them specially suitable for parts that would not be mechanically satisfactory if made of pure aluminium.

The principal economic alloys from the industrial point of view are (a) those containing copper only as the other essential element; (b) those containing copper and magnesium as the essential elements; (c) those classed as aluminium-copper-zinc alloys; (d) those rich in silicon; (e) the aluminium-magnesium alloys; and (f) the aluminium-silicon-copper alloys. With these we shall deal successively insofar as they are applicable to dock and harbour uses.

The Properties of Aluminium and its Alloys—continued

Aluminium-Copper Alloys

The ordinary " straight " aluminium-copper alloys are obtainable in either the wrought or the cast forms. Broadly, the casting alloys were formerly divisible into two main types, each governed by British Standards Institution specifications. The first was termed 4L11 and contained from 6 to 8 per cent. of copper. The other was termed 3L8, and contained about 12 per cent. of copper. Both alloys were improved by heat treatment, as will be indicated later. They were somewhat lacking in ductility, which largely restricted their use, but within the range of application open to them, they were of considerable value, although today they have been superseded by newer materials such as the RR and Y alloys.

Adding copper to aluminium improves its casting properties, there being less irregularity of contraction, less weakness as compared to a plain aluminium casting, and a finer grain structure. In the wrought alloys, the copper induces greater strength and hardness. An interesting fact is that these alloys, after heat treatment, " age," i.e. if they are left at room temperature for, say, ten to eleven days, they gradually become harder and stronger. This is the result of precipitation, i.e. in these alloys, some of the copper atoms combine with atoms of aluminium to form copper aluminium ($CuAl_2$). When the alloy is heated, this compound forms solid solutions with the surplus aluminium, i.e. is dissolved in it, and is retained in solid solution after cooling by quenching. This is known technically as solution treatment, but these solutions are unstable, i.e. they are likely to break up, and during the ageing period they deposit or precipitate out discrete particles of copper aluminide ($CuAl_2$). This goes on progressively day by day until the alloy is fully aged, and in consequence becomes much harder and stronger. Incidentally, it is possible to produce this frequently desirable effect (ageing) in hours only, by a special form of treatment. We shall see later that other alloys of aluminium also become harder and stronger when aged after the preliminary solution treatment.

Effects of Copper on Aluminium

A few other effects of copper on aluminium may be noted. The resulting alloys become denser, slightly less conductive of heat and electricity, have lower coefficients of thermal expansion, i.e. do not expand quite so much under heat, and have slightly less resistance to corrosion, though the corrosion resistance may be partly restored by heat treatment.

The cast aluminium-copper alloys are reasonably machinable, and have fairly good mechanical properties, as shown in Table II. They are less resistant to corrosion than pure aluminium. Characteristic uses of the cast alloys are for crank cases, oil pumps, transmission housings, manifolds, and other parts. They are used for other parts that are not called upon to meet severe stress or shock.

TABLE II

Type of Alloy.	Sp. Gravity.	Yield Pt. tons.	Max. Stress tons.	Elongn. o/o	Brinell No.	Izod Impact ft. lb.
4L11 (6-8% Cu) as cast	2.8-2.93	4.8	10-12	3-6	54-64	2-5
3L8 (11-13% Cu) as cast	2.9-2.95	6-7	10-14	1.5-2.5	74-87	1.0-2.5
6% copper alloy (solution treatment and aged) ...	2.82	9.5	21	13	95	8

Duralumin

The next most important alloy with which we must deal is known by the name Duralumin. This is governed by the B.S.I. specification 5L3, and is there defined as containing 3.5-4.5 per cent. copper, 0.4-0.7 per cent. manganese, about 0.4 per cent. silicon, and iron to the extent of not more than 0.5 per cent. Various modifications exist, however, such as D.T.D. 356, a wrought light alloy used mainly for sheets and strips. In these alloys the iron and the silicon are accidental impurities. Iron is generally regarded as injurious, but silicon is not, and, indeed, is often regarded as an essential constituent.

Duralumin is not new, for it was first discovered by Wilm in 1906, but it was for a considerable period the strongest of all the aluminium alloys, and its ageing property, earlier referred to in connection with the aluminium copper alloys, was of great advantage to users, even though not fully understood until 1923. Once ageing was understood, however, it was found possible to develop a considerable number of other aluminium base alloys even stronger than duralumin alloys. It is doubtful, even so, whether any of these newer materials are superior in general all-round properties to the original duralumin alloys, and for this reason duralumin still remains an extensively used alloy.

Duralumin is not now used for castings, because castings made from it are usually spongy, i.e. full of small pinholes caused by imprisoned gas bubbles, while another trouble is that particles of non-metallic type, such as oxides, or segregations, as they are sometimes termed, frequently form near the surfaces of the ingot or castings. Duralumin is essentially a **wrought** alloy.

It has a specific gravity of 2.74 to 2.79, and a density of 0.099 to 0.101 lb. per cubic inch. It may be forged, stamped, rolled, drawn and hot-worked. It is also readily cold-worked after a preliminary annealing or hot working operation. It is fairly resistant to atmospheric corrosion, more particularly after anodisation, but not to sea water. In its strongest form, it is approximately equal in strength to mild steel, though less ductile. It is, however, quite as tough, and has the advantage of being much lighter, having only about a third the weight of mild steel.

The coefficient of linear expansion of duralumin is approximately 0.000023 per 1° C., and its thermal conductivity is approximately 0.3 c.g.s. units. The duralumin alloys will withstand, without much detriment, moderate temperatures (up to 200° C.), but above these temperatures they decline in strength. Cold rolling hardens them, so that an annealing operation may be necessary if softer material is desired.

The greatest proportion of duralumin is used as extruded sections (including bars) or else forms produced from extrusions (forgings, sheets and strips).

Aluminium Alloys for Structural Purposes

Aluminium alloy materials comprising thin sheeting and small structural sections, were, for many years, confined to aircraft construction and other more or less domestic uses such as fittings in transport vehicles and household articles. Sections are now made, however, in a variety of structural shapes which have been used for bridge and other structural works.

The alloys for structural purposes may be divided into two main groups:—

(a) The Duralumins: those in which copper is the principal alloying material; these are heat-treatable alloys which require heat treatment to achieve their useful strength and other properties.

(b) The work-hardened or non-heat-treatable alloys which obtain their strength by extrusion, rolling, etc. This is the aluminium-manganese group.

The characteristics of these alloys are low specific gravity, adequate ductility, low modulus of elasticity, high coefficient of thermal expansion, high resistance to atmospheric corrosion, low resistance to electrolytic corrosion and high ultimate strength.

Structural sections are generally manufactured by extrusion and B.S. 1161 deals with the standard sizes at present manufactured and their properties. H beams are made up to 12-in. x 6-in., channels up to 12-in. x 4-in. x ⅝-in., angles up to 9-in. x 9-in. x ¾-in., tees up to 9-in. x 9-in. x ⅝-in. in lengths up to 30-ft. and longer in special cases. Plates are made up to 6-ft. wide and 30-ft. long.

Nearly all of the aluminium alloys can be arc-welded, but sections in group (a), being heat treated, are specially liable to have their heat treatment impaired locally. Other systems used are oxy-acetylene gas, carbon-arc electrodes and resistance welding is also possible. However, for structural joints, metallic arc-welding with aluminium electrodes is the only feasible method. Difficulties are experienced owing to high thermal conductivity, necessitating considerable heat and high current consumption; oxidation of the surfaces, together with corrosive action of the slag formed.

Rivetting also presents some difficulties at present, but pressure driven cold alloy rivets are now used in small sizes and hot steel rivets in the larger sizes, and this process is usually more practicable than welding. Experiments have been made with tubular alloy rivets from ⅜-in. to ¾-in. diameter and the " Ghobert " rivet has considerable advantages.

The Properties of Aluminium and its Alloys—continued

Owing to the low modulus of elasticity, deflection effects in structural work, in most cases, must be eliminated by the use of deeper beams and girders. Provision must also be made for the high thermal expansion and its deflection effects. The effects of impact, on the other hand, are much less than in the case of steel structures.

Table III gives the properties of certain aluminium alloys.

treatment in order to improve their mechanical properties. In the cast condition, these alloys, originally known as Lautal alloys, have a yield point of about 6 tons per sq. in.; tensile strength about 11 tons per sq. in.; elongation 10% in 2-in.; and a Brinell hardness about 59. In the heat-treated condition, the corresponding values are about 10 tons, 18 tons, 9%, and Brinell hardness about 95. Density is approximately 2.75.

TABLE III. ALUMINIUM ALLOYS

Material	Mean specific gravity	Weight per cu. ft. lb.	Coefficient of linear expansion at 65°F./°F. × 10^6	Tension			Compression	Shear		Young's Modulus, E, tons/sq.in.	Modulus of rigidity, G, tons/sq.in.	Poisson's ratio	Remarks
				Ultimate strength tons/sq.in.	*1 p.c. proof strength tons/sq.in.	Elongation on 2 in., p.c.	†1 p.c. proof strength tons/sq.in.	Ultimate strength, tons/sq.in.	0.1 p.c. proof strength, tons/sq.in.				
Duralumin S	2.79	174	11.5	32 (72,000)	26 (58,000)	10	27 (61,000)	19 (43,000)	15 (34,000)	4,600	1,785	.34	Precipitation heat treated
Typical work-hardened aluminium-magnesium structural alloy	2.62	164	12.8	26 (58,000)	19 (43,000)	6	19 (43,000)	15½ (35,000)	11 (25,000)	4,600 (10.3×10^6)	1,785 (4×10^6)	.34	Highly resistant to corrosion

*In lieu of yield point which is non-existent in aluminium.
†Strength in bearing is about 1.8 times tensile.
Figures in brackets are lb./sq.in.

While the structural use of these light alloys is no doubt in its infancy, fixed bridges have been built in the U.S.A. and on the Continent of Europe, together with a bascule bridge at Sunderland (described in the Dock and Harbour Authority of December, 1948) and military bridges and other applications during the war. It is probable that in the future new techniques will be evolved, and where weight saving is important, the use of light alloys is indicated in movable bridge, crane structures, dock gates and floating caissons. Saving in weight up to 40% has been attained, which naturally facilitates erection and lowers costs. Readers are referred, for further reading on the use of light alloys, to a paper read before the Structural and Building Engineering Division of the Institution of Civil Engineers in 1948, entitled " The Use of Light Alloys in Structures."

The R.R. Alloys

We now come to the R.R. Alloys, developed by Messrs. Rolls Royce Ltd., and manufactured by High Duty Alloys Ltd. These, like Y alloy, contain small percentages of nickel, and, in particular, titanium, and they are superior to other types of aluminium alloys for use at high temperatures. They are thus eminently suitable for internal combustion engine pistons. Some of these alloys are used in the cast form, others as die castings, and others again as forgings.

An interesting feature of these alloys is that their copper content is lower than in either duralumin or Y alloy. It is also interesting to note that the iron content is appreciably higher. The main purpose of the titanium is to serve as a cleansing and deoxidising medium, and it is added to the molten alloy in the form of ferro-titanium.

Heat treatment and ageing produce a marked improvement in mechanical properties. Average physical properties are: specific gravity, 2.7 to 2.75. Thermal conductivity, 0.40 c.g.s. units; coefficient of linear expansion, 0.000022 per deg. C.

Aluminium-Silicon Alloys

Silicon is a most important alloying element in many aluminium alloys, and the wide range and application of these deserve special mention. These are particularly suitable for making castings because, when melted, the alloys run freely, and after being cast are not brittle or hot-short. They do not possess particularly high strengths or hardness, but withstand corrosion to a marked degree, are extremely light in weight, and are good conductors of heat and electricity. In this country, the alloy of this type most commonly employed is L.33.

Some alloys whose silicon contents are 2 to 3% are also used. These generally contain approximately 4% of copper, and have been principally developed on the Continent. They can be either wrought or cast, and are usually subjected to some form of heat

Aluminium-Magnesium Alloys

The next group of alloys with which we must deal are the aluminium-magnesium alloys. Magnesium is important as an alloying element because of its extreme lightness, and for this reason research into its use has been going on for about 48 years. Magnesium is lighter even than aluminium, and in consequence, the alloys in which it is employed are necessarily lighter than most other aluminium alloys. Such metals are highly resistant to corrosion, have excellent physical properties, and are readily machinable. The one drawback is that magnesium is rather costly to manufacture, and this to some extent limits the economic application of the aluminium-magnesium alloys. They are less dense in proportion as the magnesium percentage increases, but have a higher coefficient of thermal expansion, which again increases proportionately to the increase in the percentage of magnesium.

The presence of magnesium in these aluminium-base alloys lowers their ability to conduct electricity and heat, the decline being roughly proportional to the magnesium percentage. Both cast and wrought forms are available. There is no special trouble in making aluminium-magnesium castings, the alloys flowing freely when molten, and not giving rise to undue brittleness or hot shortness when cast, while cracking during cooling and heat treatment is not likely if the proper technique is employed. On the other hand, the alloys are less suitable for pressure-tight castings because of their lower density as compared with the aluminium-silicon alloys.

Aluminium-magnesium alloys are much used in sheet form, especially for those purposes where resistance to sea-water corrosion is important.

Heat-treatment, properly carried out, improves their general properties. Forging or rolling of ingots of this material is perfectly feasible and presents no great difficulty as long as the magnesium content does not exceed about 3.0%. Above this figure, the alloys rapidly harden and become more difficult to forge or roll, and even when their working temperatures are high, it is quite common for cracks to develop. Hence, it is seldom that alloys of the wrought type contains a higher proportion of magnesium than 6.0%, except for special purposes that warrant high cost, when small quantities of sheets of restricted dimensions with magnesium percentages up to 10% may be required. At the same time, it should be noted that extrusion processes may be carried out with alloys containing as much as 25% of magnesium, but the speed of the operation declines as the percentage of magnesium increases.

Reverting to wrought alloys of this type in general, attention may be drawn to the noticeable decline in tensile strength with increasing magnesium contents above 15%, but this is not accompanied by a parallel decline in yield point and hardness, which rise continuously with increased magnesium contents. The elongation per cent. remains fairly constant up to about 12% of magnesium,

The Properties of Aluminium and its Alloys—continued

being in the region of 32% in 2-in. Impact resistance rises with the magnesium content and is considerably higher than, for example, that of duralumin, at all events for magnesium contents up to 6% magnesium, after which the improvement is less marked.

Aluminium-magnesium alloys retain their mechanical strength at elevated temperatures more effectively than do the aluminium-silicon and aluminium-zinc alloys, but are not quite so good in this respect as the aluminium-copper alloys. Their corrosion resistance, as already explained, is good, even when marine corrosion is involved, and these alloys are superior to most other aluminium alloys in this respect, retaining their strengths longer and exhibiting a better appearance after long periods of exposure than most other aluminium alloys, particularly those in cast form. They also offer some resistance to corrosive attack by alkalis.

It will be appreciated that in the preceding notes we have confined ourselves primarily to the more commonly used alloys of industrial and engineering types. Space does not allow of an exhaustive survey of every different aluminium-base alloy produced. Many of these overlap, so far as function and properties are concerned, or the differences between them are so slight as to be negligible. Again, some alloys have been adopted in different countries as substitutes for others either identical or nearly akin in characteristics, not because of any special advantages to be gained by their use, but because there happens to be a shortage of some particular alloying element in the country in question. It will be obvious that to pursue all these alternatives would merely be to overweight the reader with a mass of data unlikely to be of any immediate use. A list of the different metals with which aluminium has been alloyed has already been given. The reader desiring to study these less orthodox alloys is referred to more detailed literature on the subject.

Experimental Timber Groyne

Erected for Coastal Defence at Shoreham

By R. P. WOODS, B.A.For. (Cantab.)

The flood damage caused by the abnormal storms of January last cannot fail to bring home to all the importance of coastal defences in which wood plays such a vital role. The Timber Development Association has been aware of a Problem which was, and now is, facing the various authorities with the utmost gravity, namely, the finding of suitable timbers for this very important use. This point will be appreciated when it is realised that the most popular timber for groynes it pitch pine, closely followed by greenheart. In the softwood field Douglas fir is beginning to replace pitch pine, but its life is not comparable; and this in turn is dependent upon the conditions existing on that part of the coast which is required to be protected.

The greatest enemy of timber, or for that matter of any other material, is scour or abrasion caused by movement of the beach material, as exemplified in Fig. 1 which shows only too clearly this damage.

Fig. 1. Groyne showing the heavy abrasion caused by shingle.

The South Coast of England varies considerably from place to place, but the stretch between Worthing and Brighton is of considerable interest due to the littoral drift of the shingle from west to east, i.e. up the Channel. To reduce erosion of the coast, groynes are erected to prevent this shingle movement and so build up a protective barrier for the low-lying land behind the banks of shingle.

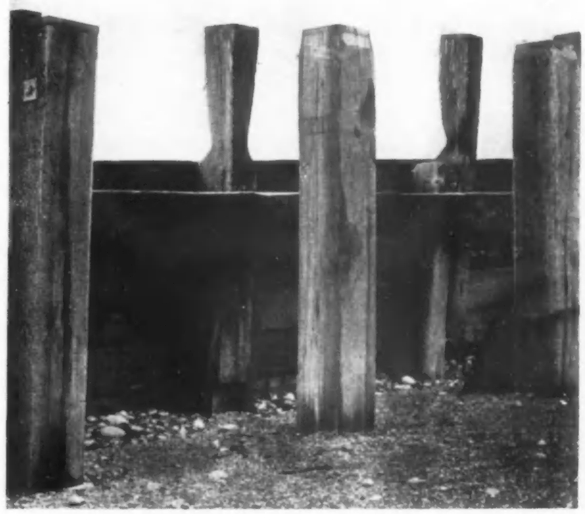


Fig. 2. Experimental Groyne showing wallaba, greenheart and mora piles.

Full details of the timber requirements for groynes on this particular stretch of the coast are given below, and indicate the amount of timber which is used.

Pocket Section 70-ft.
14 piles, 9-in. x 9-in.; lengths 4/10-ft., 4/11-ft., 4/12-ft., 2/13-ft.
80-ft. run of 6-in. x 9-in. waling 17-ft. and up.
350-ft. run of 3-in. x 9-in. planking in 15-ft. and 20-ft. lengths.

Main Section 120-ft.
25 piles, 9-in. x 9-in.; lengths 4/14-ft., 8/13-ft., 8/12-ft., 5/11-ft.
130-ft. run of 6-in. x 9-in. waling lengths of 17-ft. and up.
700-ft. run of 3-in. x 9-in. planking in 15-ft. and 20-ft. lengths

Spur Section 65-ft.
13 piles, 9-in. x 9-in.; lengths of 5/11-ft., 8/10-ft.
70-ft. run of 6-in. x 9-in. waling 17-ft. and up.
250-ft. run of 3-in. x 9-in. planking in 15-ft. and 20-ft. lengths.

Many specifications, however, could be re-examined in the light of present-day supply problems since some are too exacting, with the result that it is practically impossible to satisfy them out of existing stocks.

This work of coastal defence is in the hands of the Shoreham and Lancing Sea Defence Commissioners, whose co-operation and gene-

Experimental Timber Groyne—continued

rosity in giving facilities for erecting an experimental groyne is gratefully acknowledged. The timbers used are greenheart, mora and wallaba. The first is known to be resistant to teredo and, to a certain extent, against scour; the second is known to be non-resistant to teredo, but this factor need not be taken into consideration in the main section of the groyne. The last mentioned timber could be called a problem wood; its high oily content causes considerable trouble in normal markets, but it was felt that its other useful properties might find an outlet in this very large field of utilisation.

Each individual pile has been marked with an identification letter (see Fig. 2) so that comparative behaviour of each wood can be observed. As far as pile driving is concerned, it has been found that mora is the best and that wallaba tends to split and shatter under impact. This tendency is greater than in greenheart. A Douglas fir pile, normally used, has been driven in the centre of the groyne as a control.

Behind the new piles in Fig. 2 can be seen the old groyne which is being replaced by the T D.A. groyne. The former has stood up well to conditions having been in position some 30 years, but it has had repairs from time to time. The planking and walings will be placed in such a manner that each timber will receive the same amount of abrasion. When the groyne is completed the old one will be withdrawn thus letting the full force of the shingle drive on it and thereby subjecting it to a full test.

Facilities for testing any timber, whether for a complete groyne or merely individual pieces, have been arranged with the Shoreham and Lancing Sea Defence Commissioners. Details can be obtained from the T.D.A. The next experiment to be conducted by the Association will be to determine whether round piles are superior to the square ones normally used.

Lest it be feared that the T.D.A. experiments are going to interfere with old established markets of certain sections of the trade, it must be made clear that this is not the case. If a coastal authority is satisfied with the timber they have used in the past, and can get supplies to-day at a competitive price, then nothing the Association is doing should alter their opinions. If, however, supplies are not satisfactory, then the aforementioned experiments will assist in finding alternative woods, thus protecting a market for timber in the face of growing competition from alternative materials.

The more that can be learned about timbers and their suitability for specific purposes, the wider the market application of wood, but in most cases this can be achieved only by practical tests. The results of actual experiments are the best source of information on the behaviour of timbers for specific purposes.

Tank-Cleaning Plant at Cardiff

The Mountstuart Dry Docks Company has recently completed a new tank-cleaning plant at the Roath Dock, Cardiff, where tankers of up to 31,000 tons d.w. can be accommodated.

The new plant, which was designed by the senior executives of the Mountstuart group to gas-free and clean the tanks of oil tankers after cargo discharge, will make it unnecessary for tankers to proceed to sea to clean their tanks, and so will help to reduce the incidence of oil pollution.

The new facility is completely self-contained, and consists of a large boiler, an oil-separator, filter and oil-storage tanks. Ship tanks are washed out by the Butterworth system, and the oily ballast pumped ashore through the separator and filter, from which the separated oil flows into the storage tanks and the water is discharged into the dock. The separator is completely enclosed and both it and the oil storage tanks are protected against fire by a new method, in which the space between the surface of the oil and the top of the tank is filled by an inert gas under slight pressure.

The plant complies with the requirements of the Home Office and embodies all the recommendations made by Dr. H. E. Watts, H.M. Chief Inspector of Explosives, in the report on his investigations into the causes of the explosion and fire at the Avonmouth Oil Depot in 1951. It has already successfully dealt with two tankers belonging to the Anglo-Saxon Petroleum Company, Ltd., the first being completed in two days and the second in three days, before proceeding to the repair berths.

Correspondence

From The Rt. Hon. **The Earl of Lucan, M.C.**

To the Editor of *The Dock and Harbour Authority.*

Sir,

The Future of U.K. Ports.

The Transport Bill has now passed into law, but the debates in Parliament have left unanswered a number of questions, not least of which is the future of the ports of this country.

Clause 19 of the new Act repeals the whole of those clauses of the 1947 Act which established the Transport Commission as, in effect, the planning authority for the "trade harbours." When asked what machinery was to take its place, the Government spokesman in the House of Lords replied that they would rely on the pre-1947 procedure of promotion of Private Bills for the development of port facilities. It was clear that the Government's sole aim was to restrict the powers of the Commission, and that they had given little thought to a co-ordinated policy of port development.

Whether the wide power of acquisition given to the Commission by the 1947 Act were necessary or judicious is an arguable point, and in any case these powers could have been curtailed by minor amendments without wholesale repeal of Clauses 66—68. What is surely incontestable is that something more than a 19th Century laissez-faire system is required to ensure that our port system is kept continuously modernised and adapted to present-day conditions.

It is common ground that we can only solve our economic problems by bringing all parts of the industrial machine to maximum efficiency. Would anyone maintain that the sea-ports can play their full part in the economic battle by unaided private enterprise? It would be folly to forego economic efficiency for purely political reasons.

11, Hanover House,
London, N.W.8.
May 7th, 1953.

Yours faithfully,
LUCAN.

To the Editor of *The Dock and Harbour Authority.*

Sir,

British Inland Waterways.

I should like to express my gratitude for the space given in your April issue to my recent Paper at the Royal Society of Arts; and in particular for your comments and criticisms, as constructive as they are informed and influential. I venture only to suggest that I did not fail to "indicate any line of policy for the Transport Commission in its dilemma." The main intention of the whole Paper was to suggest that the time has come when the policy of piecemeal abandonment of waterways (a policy initiated and sustained by the former railway companies) should itself be abandoned; and that the entire waterways system be placed under the supervision of a newly constituted National Waterways Commission, upon which would sit representatives of all the different waterway functions, many of which, such as land drainage, water supply and amenity, are of steadily increasing importance. These functions should not be considered or administered in isolation from the function of commercial carriage. Concurrent and cumulative consideration of all would be to the advantage of all.

The present plight of the waterways is closely connected with the extreme degree of atomisation which attends their government. I am pleased to note that your Editorial Comment does not widely differ from this view. Finally I should like to say that neither I nor my Association are primarily "fascinated by the more romantic aspects of narrow canal working," attractive though many of these aspects undoubtedly are. We favour expansion and modernisation of the industry, and, not least, much more extensive and efficient salesmanship; and see no reason why much that is good about the old should not be carried forward into the new.

Inland Waterways Association,
11, Gower Street,
London, W.C.1.
May 8th, 1953.

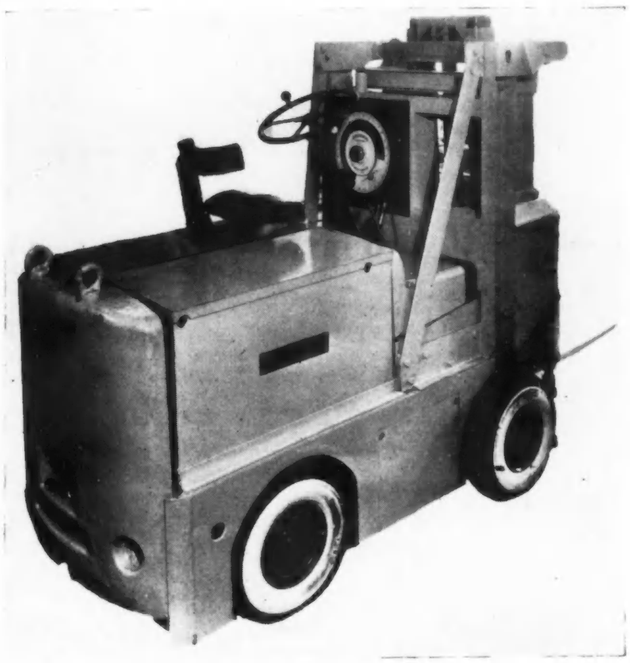
Yours faithfully,
ROBERT AICKMAN,
Vice-President.

Manufacturers' Announcements

Fork Truck with Weight Recorder

One of the most serious impediments to the efficient handling of materials is caused by the time taken to weigh materials—particularly in those industries where accurate weight is essential.

Where Fork Trucks are used, the inherent speed of the system is very often offset whilst materials are taken out of the "flow," placed on to a static weighing machine, and then picked up again after weighing has been carried out. This applies particularly to cargo handling at docks where present procedure necessitates three distinct handling movements when transferring cargo from ship to transit shed or lorry, or visa versa.



After many years' research, a weighing device, known as the "Wheelerweigh" has been invented which enables the goods to be carried by truck, after being unloaded from the ship, directly to the transit shed or lorry. While the truck is in motion, the goods are automatically weighed; thus, with this new method, two of the handling movements are eliminated.

The Wheelerweigh is a precision weighing instrument designed for installation integrally with the Stacatruc Fork Lift Truck, on which, by simply depressing a small lever, the actual net weight of the load on the forks is instantly and clearly visible on a large dial. The new instrument is built in accordance with the latest recognised weighing machine practice, and indicates all weights to fine limits of accuracy. It is fully approved by the British Board of Trade Standards Department, and should therefore satisfy the official regulations laid down by all national bodies governing the use of weighing machines for trading purposes.

Fitting the new instrument to the Stacatruc is relatively simple. It can be applied to either small or large Stacatrucs and calibrated up to their full carrying capacity. It is equally suitable for petrol, diesel or electrically driven types, and can be installed on existing models.

The Weighing Equipment is locked and rigidly held until the operating lever is depressed, so that while the truck is in motion or handling loads which do not require to be weighed, the mechanism is completely relieved of all loads or shocks. It is also totally enclosed and cannot be tampered with.

The weight is shown on a large engine-divided dial with widely spaced equal divisions which can be easily read by the driver, or by the tally clerk. Readings can be in lbs., kilos or to any standard of weight. The weight of pallets or any other accessory can be instantly tared off, leaving the actual net load shown on the dial. The dial is fully illuminated when the weigher is in commission, and can be positioned either across the vehicle or arranged for side reading as desired.

With this device, the general utility and manœuvrability of the vehicle are in no way impaired. The weighing mechanism has been specially designed to withstand rough treatment, and the actual weighing device is completely locked until the operating lever is depressed and, in fact, becomes an integral part of the machine into which it is built.

The manufacturers are I.T.D. Ltd. (Industrial Truck Development), 95-99, Ladbroke Grove, London, W.11.

The Use of Protective Barrier Creams

During the recent war, when the incidence of occupational dermatitis increased to an alarming degree, considerable research was devoted to the problem of the prevention of dermatitis by the use of scientific barrier creams The result was that a range of creams was produced which fulfilled all the essential requirements of the perfect barrier cream as laid down by an eminent medical authority. For this reason they are specifically recommended by dermatologists, while their ever-increasing use in all types of industry throughout the world is a further testimony to their efficiency.

Barrier creams have now been evolved which afford complete protection against irritant materials or liquids making contact with the skin, and which have a bacteriostatic value which safeguards infection. They are of a creamy consistency, are easily applied and quick drying, and can be used on the hands or face. The soluable type of cream is readily washed off with hot or cold water and the water repellent type gradually wears off after a period of three to four hours, after having served its purpose. The creams become invisible on application, forming a thin yet tough flexible film which resists the penetration of irritant substances, but at the same time allows the hands to remain free and mobile for all types of manual work.

To meet the wide range of substances, processes and combinations of processes which are found in the industrial world, a variety of creams have been produced. In the dock industry, for example, the loading and unloading of ships necessitates the transportation of heavy loads between dock and vessel, to and from trucks, freight cars, warehouses, etc. The men, working in all kinds of weather, are subject to skin disorders caused by irritating and poisonous dusts from such cargoes as grain, minerals, coal and chemicals. The lead, manganese, arsenic and silica content of many substances (e.g. cement, basic slag and other artificial fertilisers) are sources of irritation, while fumes from tank ships carrying mineral oils may cause poisoning, despite automatic unloading.

Water repellent barrier creams are available for dock workers which give protection against wet jobs involving chemical vapours and solutions. Water soluble creams give protection against oils, solvents, greases, bitumastic products, paints, tar fumes, etc.

A practical demonstration of the effectiveness of such preventative measures was recently given by the Technical Advisory Service of Innoxa Laboratories, 1, Eden Street, London, N.W.1, who during the last ten years have evolved various types of barrier creams for use in many different industrial processes which call for skin protection.

Obituary

Mr. James Alexander, C.B.E.

We regret to announce the sudden death at his home in Belfast, at the age of 61, of Mr. James Alexander, general manager and secretary of the Belfast Harbour Board since 1945.

Entering the Harbour Commissioner's service in 1908 as an apprentice clerk, Mr. Alexander became chief committee clerk in the general manager's office in 1922. Six years later, he was appointed chief assistant to the secretary and in 1940 assistant to the general manager. During the last war he was deputy chief executive of the Port Emergency Committee.

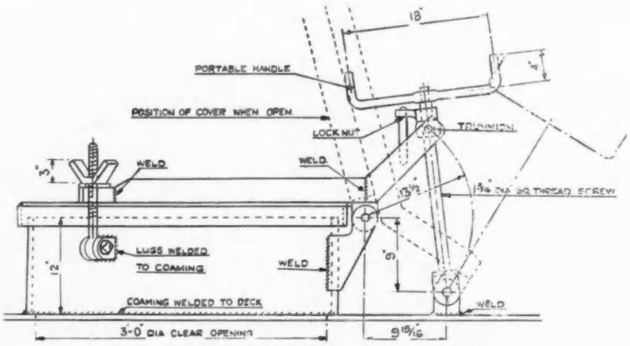
Mr. Alexander was the Northern Ireland representative on the executive committee of the Dock and Harbour Authorities' Association, and was a former chairman of the Northern Ireland section of the Institute of Transport. He was appointed a C.B.E. in the Birthday Honours in 1951.

Manufacturers' Announcements—continued

Simplified Hatch Cover for Tankers

A new design of hatch-cover has recently been patented by Messrs. Swan, Hunter & Wigham Richardson, Ltd., Newcastle-on-Tyne, and Mr. T. Guthrie, M.B.E., naval architect and technical manager of that Company, for use on cargo tanks in oil tankers.

For many years past, the regular practice has been to seal hatch-covers by closely spaced toggles, which meant that the opening and closing of hatches was a slow and laborious task. A block and tackle was usually employed to raise the covers of the hatches, but when closing, the covers were often allowed to fall with the result that the packing was damaged and its life shortened. The new cover, known as the "Easifast" design, eliminates these objections, whilst still maintaining a hatch which is easily constructed in the shipyard and without the necessity of using expensive hydraulic presses and dies. It is adaptable to suit round, oval or rectangular coamings being strengthened by perimeter and other stiffeners to permit the reduction in the number of fasteners necessary to secure oil tightness. With the older type of hatch, eight fasteners are normally used, but with a 4-ft. dia. hatch, only three fasteners are needed. In the prototype hatch of this size, the cover



Elevation of Hatch in closed position.

was tested to a head of 29-ft. before showing signs of leakage (Lloyd's test for the hatches is 8-ft. head). The raising and lowering of the hatch cover is carried out by means of a screw gear, the lower end of which is secured to the deck or to the hatch coaming, depending upon the height of hatch coaming required.

Two of the cover stiffeners are extended over the hatch side to form a lifting lever, and a trunnion in which the screw works is fitted between the ends of these stiffeners. The turning of the screw in this trunnion raises or lowers the cover as required. Normally the hatch cover remains stationary in any position, but to provide additional security, a lock nut is fitted above the trunnion to lock the cover at any position. The lock nut is fitted with a hinged drop handle which, when not in use, falls down between the stiffeners so that when the screw is operated the lock nut raises and falls with the trunnion, and does not need to be operated separately.

The cover can be opened fully by one man in about half-a-minute and lowered in a few seconds, and the smaller number of fasteners means that the final tightening can be performed in about one quarter of the time required for a normal cover of the same size.

Prior to the design being put on the market, one of the large tanker owners permitted the fitting of three hatch-covers to bridge-front hatches of one of their ships, and after a year's service, a satisfactory report was given. Nearly 4,000 covers have since been ordered and 16 shipyards have applied for construction licences.

Cathodic Protection Specialists Collaborate.

F. A. Hughes & Co., Limited and Westinghouse Brake & Signal Co., Limited, pioneers of cathodic protection, are collaborating and pooling their respective experience of this scientific method of corrosion prevention with the object of offering their combined technique in the most practical and comprehensive form now known as The Guardion Service. This embraces the supply of the well-known "Guardion" and "Westalite" Cathodic Protection Equipment, and offers full consultative and design facilities as well as surveys in the field. It is applicable to all forms of buried or water-immersed metallic structures. Full particulars can be obtained from F. A. Hughes & Co., Limited, Cathodic Protection Division, Bath House, 82, Piccadilly, W.1.

Three Dredgers for Burma

Lobnitz & Co., Ltd., Renfrew, have received an order from the Government of Burma for three self-propelled cutter suction dredgers. They will have a length of 134-ft., a breadth of 29-ft., and a depth of 8-ft. Material will be raised by suction through a pipe with a 16-in. bore and it will be discharged by means of a pipe line. The propelling machinery in each case will consist of a Lobnitz totally enclosed steam reciprocating engine. Upon completion, the dredgers will be dismantled and shipped to Burma.

Port Control at Dover.

An order has been placed by the Dover Harbour Board with Rees Mace Marine, Ltd., to equip the port of Dover with V.H.F. radio-telephones for port control. The central station will be installed in the signal tower on the eastern arm. Tugs operated by the Board will be equipped with multi-channel V.H.F. mobile sets to enable them to communicate either with the signal tower or with other ships fitted with V.H.F. It is hoped that ships regularly using the port will also fit radio-telephones to utilise the service to the maximum efficiency.